AMENDMENT TO THE CONTROL OF ASBESTOS AT WORK REGULATIONS 1987 AND ACOP

REGULATORY IMPACT ASSESSMENT

CONTENTS

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ISSUE

1 Asbestos has been responsible for more occupationally induced deaths than any other single cause. Since asbestos can result in death 15-60 years after exposure, the current mortality rate, which is expected to rise until at least the year 2010-20, is largely determined by the level of exposure before the introduction in the 1980s of modern and more stringent asbestos legislation. Nevertheless, we believe the *current* risk of exposure to asbestos may remain significant.

2 HSC previously consulted on a range of measures to further tighten legislation to enhance protection for those working with, or affected by, asbestos containing materials. This RIA sets out the costs and benefits of applying a duty to manage the risks from asbestos in commercial buildings and the common areas of residential property. The issue of whether to include other areas of residential accommodation in the proposals will be considered at a later date.

OBJECTIVES

3 The objective of the amended regulations is to further reduce the risk of future exposure to asbestos by requiring a duty to identify and manage the presence of asbestos in buildings. The amended regulations will also fully implement the Chemical Agents Directive, including a requirement for a written plan for work that is liable to disturb Asbestos Containing Materials (ACM).

OPTIONS CONSIDERED

4 HSE commissioned an initial feasibility report (by RPS Thomson: see below) which has assessed the various options available. HSC has previously consulted on two other options regarding the scope of the duty to manage, namely a comprehensive duty to identify and manage asbestos in pre-1985 buildings, and a duty to identify and manage on pre-1985 buildings when changing ownership. HSC also previously consulted on an option requiring the total removal of ACM present, rather than allowing for a continuing risk management system. The seperate issue of whether to include residential accommodation will now be considered at a later date. The two remaining options considered in this RIA can be broadly categorised as follows:

a <u>Amend existing regulations</u>. This would involve clarifying or amending existing legislation so that risk assessment and client duties include specific reference to asbestos. The major advantages of this are that it would mean that the 'risk assessment' would require a management plan to control the risk from all types of asbestos, and this would be directly targeting those most at risk. The implication for the employer/owner is that they would maintain the right to view their own property and decide on action (provided that doubtful materials are treated as containing asbestos), rather than having to have a survey undertaken in all cases. The ACoP would apply to all workplaces and public buildings.

b <u>‘Do nothing’</u> in legislative terms, but provide more information to public/employers on recognising the risk from asbestos etc, and improve the enforcement of existing regulations.

5 The calculations underlying the costs and benefits of HSE’s preferred option, option a, are set out in detail in the annexes to this document. The two options are then separately assessed in the comparison of costs and benefits section below.

CHANGES MADE SINCE PREVIOUS CONSULTATION

<u>Changes to the number and size of buildings</u>

6 We have made a very significant change to our estimates of both the total number and size of commercial buildings since the second consultation. This followed the publication of new and much improved figures from the Valuation Office. The publication ‘Commercial and Industrial Floorspace and Rateable Value Statistics 2000’ was published in October 2001, several weeks after the publication of the previous CD. The Valuation Office figures were calculated on a significantly different basis to the previous estimates from 1995, both in the type of buildings included in the four bulk classes (factories, offices, shops, warehouses) and the amount of floorspace excluded from the statistics. We had previously combined the 1995 figures with information provided by RPS Thompson to estimate total UK floorspace.

7 On reviewing the methodology in the light of the new and more complete floorspace statistics from 2000, we discovered that we had substantially over-estimated the total floorspace of factories/industrial buildings. The main implication of this re-estimation is that survey costs are significantly reduced, since these are essentially determined by the floorspace data. Remedial costs are less affected, because of the estimates are partly made on a per building basis. Total factory costs have therefore been dramatically reduced and, as these previously represented more than two-thirds of the total for commercial premises, the effect has been to roughly half the cost of the proposals.

8 Further investigation also uncovered a 1997 research report from the Open University, referenced below. This report, covered all non-domestic buildings and provided numbers and estimates of floorspace for the majority of those buildings not included in the Valuation Office figures. This has resulted in a greater degree of accuracy and we would not now anticipate any further significant changes to floorspace estimates.

9 We now make cost estimates on a `per premises’ basis. A premises may contain several buildings, and we initially attempted to account for this. However, using the new valuation office data, it is more convenient to work on a premises (or heriditament) basis. This does not affect our estimates per se, although it does mean that care has to be taken in comparing current estimates of premises numbers with the previous building estimates.

Other changes to costs

10 As with the first consultation, many comments on the RIA from consultees centred on the estimates of the cost of asbestos surveys. In response to previous comments, we had already added two extra components to the cost of an asbestos survey. The first was a cost equivalent to an extra 50% of the survey cost, up to a maximum of £150 per building, for the preparation and marking up of drawings and plans. Secondly, we had added a ‘call out’ fee of £200 to the cost of a survey. This call out charge was adjusted for each building category according to the average number of buildings at a typical site.

11 Despite these changes, several respondents commented that our survey costs were too low. However, it was evident that these respondents were taking the call-out charge to be the full survey cost. Our full survey cost was in fact significantly higher when compared to an example quoted by a respondent who wished to demonstrate that our figure was too low. As a result, we have made no major changes to survey costs. On advice, we have increased the call-out charge to £250, and the maximum cost for drawing and plans is now £250 on a per premises basis (some premises will be very large).

12 The Asbestos Cement Products Producers Association (ACPPA) questioned several areas of cost they read as being missing. Some of these were not societal costs, and their inclusion would have been double-counting (for example legal compensation is a loss to one party but a gain to another). However, they did ask whether we had included both replacement materials and labour (re-instatement). As a result, we sent more details of our estimates of asbestos removal costs to the Association of Asbestos Removal Contractors, and also a major demolition company that routinely removes asbestos before demolition. Both organisations broadly supported our estimates as covering all resource costs, including both re-instatement and removal. They did, however, suggest higher figures for some building types, which have slightly raised our estimates. Importantly, they both said our estimates of removal costs from factories were reasonable.

13 Local authority respondents have queried enforcement costs during both consultations. Initially, these we not estimated since enforcement in this area is expected to be properly considered as part of the full review of the Enforcing Authority Regulations currently being carried out by HSE. However, we have now conducted a preliminary assessment of enforcement costs. These are estimated to be in the region of £5 million in the first year the proposals come into force. Over a ten year period enforcement costs are currently estimated at just over £20 million in present value terms.

14 Finally, we have made an estimate of the proportion of costs in the rented housing sector that relates to common areas of the building and will therefore fall in scope of these proposals. Previously, these costs were included in our assessment of the proposals relating to rented housing. The estimate provided in the cost section below is only approximate, but it does indicate that this element of cost should be modest in comparison with total costs in either the commercial or the rented housing sector.

Changes to the risk assessment procedure

15 We have reviewed the previous risk assessment, and made a number of changes. The previous approach started by estimating long term average exposure levels in broad categories

of job. This presents a difficulty in the treatment of job mobility. We have therefore re-estimated exposure patterns starting with an estimate of the distributions of exposure levels on a typical (current) working day (see paragraphs A18 to A61). The effect of this changes is to suggest lower long term average exposures for the more highly exposed groups. The number of predicted annual mesotheliomas, and the number and proportion of predicted lung cancers is reduced.

16 We have used the latest Government Actuaries Department (2000 based) population projections, and now make proper allowance for the improved levels of survival of the population into the age groups at which mesothelioma (and lung cancer) deaths are most common. This increases the number of predicted deaths, and largely offsets the reductions from the revised exposures.

17 We have corrected an error in the calibration of estimated current exposure levels with the exposure index of the projection model. In our previous calculations the projected annual deaths (to age 79) from the exposure assumptions was aligned with the projection model tokens for ages to 89. Since the intention was only to counts deaths up to age 79 (the prediction of rates at older ages being highly uncertain), the effect of these error was to underestimate the implied level of the exposure index in the projection model corresponding to the predicted annual total of deaths. The number of predicted deaths is unchanged.

18 We have also conducted a fuller quantitative examination of the uncertainties underlying these risk estimates. This is discussed in detail in Annex B, and a summary is contained in the uncertainties section below.

Changes to the baseline of risk estimation

19 We had previously made as significant change in the baseline, and we have further refined this change. In response to previous comments, we had allowed for a reduction in future risk due to the routine demolition of buildings. Existing regulations will apply on demolition, but the benefits of any asbestos management programme ceases at this point. Data from the valuation office suggested an average building life of fifty years. We therefore previously reduced both the costs and benefits attributable to the proposals by 2% each year.

20 We have since pursued data on demolition in the commercial sector from a number of governmental and industry sources. We have not been able to estimate a global figure for demolition. However, we know from our work on housing that the demolition rate for the cohort of older buildings containing asbestos will rise on a yearly basis, as these buildings reach the end of their lives. We therefore apply a demolition rate of 1% of current stock a year currently, rising to 4% by the end of the period, and giving an average of around 2%. The effect of this change is to slightly increase benefits, since commercial buildings on average last longer from the present and the ongoing benefits from establishing a management system continue for a longer period. The effect is through discounting, rather than any change in the average demolition rate.

OTHER INFORMATION SOURCES AND TECHNICAL ASSUMPTIONS

Discounting

21 We discount costs at a rate of 6% per year, in real terms, following HM Treasury guidelines. Discounting allows for individuals' observed preferences towards current spending, and for the benefits of rising real income over time.

22 Benefits are discounted at 2%, again following HM Treasury guidelines. This is to allow for individual's observed preferences for current consumption (consumption in this case being the benefits of risk reduction) over future consumption. The sensitivity of the estimation of benefits to the discounting rate is very significant, and is discussed in the uncertainties section below.

Appraisal period

23 Costs are estimated over the period 2000-2050, as in the previous analysis. In the original document, we supposed that at this point there would be very little asbestos left in buildings. Benefits also cease at the year 2050. However, because of the latency effect, fatalities prevented (at time of death) continue up to the year 2100. This is an unusually long period for analysis. The period is chosen so that benefits and costs are comparable, given the long latency periods of asbestos related disease.

24 Given our revised baseline, we now believe that some one-third of all buildings currently containing asbestos would still be standing in the year 2050. However, we do not intend to extend the appraisal period past this point. This is because the majority of costs incurred under the proposals will be upfront, and in any case both costs and benefits incurred past the year 2050 would be severely discounted. Moreover, the current appraisal period is over a sufficient length of time to ensure that the balance of (mainly one-off) costs against recurring benefits would be relatively insensitive to extending the appraisal period.

25 The base year for the estimates is still 2000. We have concentrated on refining the modelling procedure, rather than moving the base year forward. In practice, due to the removal of ACM in the intervening period, both costs and benefits are very slightly over-estimated. We believe that this will have little or no effect on the overall cost-benefit balance of these proposals.

Baseline of analysis

26 As already noted, we allow for a reduction in future risk due to the routine demolition of buildings. Beyond this, we cannot differentiate between management action that would in the future be attributable to these proposals, and action to manage ACM (other than demolition) that might have taken in place in any case, or has already been put in place in anticipation of these proposals. This document therefore presents a cost-benefit assessment of the concept of managing the presence of ACM - along the lines proposed - regardless of whether this would have been increasingly undertaken even in the absence of these proposals.

Coverage

27 Costs and benefits are calculated on a GB basis. Where any figures are available on a more restricted basis, these have been grossed up to GB as a whole, usually in line with whole population estimates.

RISK ASSESSMENT

28 A detailed risk assessment is at **Annex A**. We now estimate that around 9,000 individuals would go on to contract a fatal asbestos related disease in the absence of *any* further management action, given our best estimate of the future risk from asbestos. Removing those who are only exposed at an ambient level reduces this total to 7,800.

29 Because of the long latency period associated with asbestos related diseases, these fatalities would not, in the absence of the proposals, have happened until well after the risk control measures are in place. The fatalities prevented rise steadily over the appraisal period to a maximum of 159 per year. The average number of future fatalities that could be prevented is around 78 each year. Because of the long latency, the discount rate (of 2%) has a significant effect on the valuation. For example, the estimated 95 lung cancer and mesothelioma fatalities prevented in 2042 each have a value of only 40% of the current fatality prevention value.

BENEFITS

<u>Valuation of total risk</u>

30 A detailed discussion of benefits is at **Annex B**. Applying the current Department for Transport (DfT) value of risk reduction (£1.06 million in 2000 values) to the 7,800 fatalities identified in the risk assessment, discounted at 2% for each future year - and doubling the figures to allow for a particular aversion to carcinogens - this risk reduction is equivalent to a benefit of £4.8 billion in present values. An assessment of the accuracy of these estimates is given in the “uncertainties” section below.

31 We believe that management of ACM, coupled with full and widespread occupational training and control aimed at limiting exposure, will almost entirely remove these risks in commercial and public buildings. The risk remaining will be in residential accommodation, which is estimated below to be 39% of the preventable fatalities. The total safety benefit avoidable by this approach is therefore estimated at around 61% of £4.8 billion, or £3.0 billion, rounded to the nearest £100 million. In the same way, the number of deaths avoided in the commercial sector is 61% of 7,800, or 4,700 (all figures are rounded from exact calculations).

<u>Residual risk</u>

32 The significant area of risk that will remain is that relating to residential accommodation, including any maintenance work which is done on this accommodation. The model used to provide our best estimate attributes 58% of total risk from occupational exposure sources, such as maintenance workers. The other 42% of the total risk is attributable to exposure of the people working/living in buildings containing asbestos. Of this 42%, the

model attributes 17% of total risk to residents in all housing types. In addition around 32% of maintenance and repair activity is conducted in private housing and 20% on public housing.

33 Private housing is known to contain far less asbestos than local authority provided housing. A generous assumption would be that private housing - on a unit by unit basis is four times less likely to contain asbestos than publicly provided housing (or equivalently a private house containing asbestos will contain one-quarter the amount of that found in local authority accommodation that contains asbestos). This together with the above figures indicates that around 7% of total risk will be in the owner occupied sector and around 29% in the local authority and rented sectors, giving a total of 35% after rounding. Some of this risk will relate to common areas of residential accommodation, which are included in these proposals and costed below.

34 The majority of occupational exposure occurs in the commercial sector, whereas background exposure is split approximately evenly between the commercial and residential sectors. This is consistent with the fact the commercial and public buildings sectors contain more asbestos and thus account for the majority of occupational risk from workers conducting maintenance work. Looking at background risk, the split between the sectors is around parity due to the longer time exposure of residents of housing compared to occupants of workplaces, and the greater population estimates.

35 It should be noted that the above proportions relate to *current risk.* Since our model estimates a lower demolition rate amongst the residential sector, in the future the proportion of risk in the residential sector will increase. This can be demonstrated by the fact that although the residential sector accounts for 35% of current risk, 39% of preventable deaths are estimated to occur in this sector.

36 There may be some reduction in this residual risk from full compliance with both current regulation and the proposed Worker Protection Directive. We believe that effective compliance with the control elements of this Directive in the residential sectors are unlikely without knowledge of the presence and location of asbestos. We therefore conclude that the reduction in residual risk from the directive is likely to be small, but we are unable to quantify the exact scale of any benefits attributable solely to the Directive.

Cost savings

37 A proportion of notifiable asbestos removal and encapsulation jobs derive from unplanned disturbance of asbestos by maintenance personnel. This normally occurs where personnel have not been informed about the location of ACMs or the presence of ACMs has not previously been identified. The new duties should significantly reduce these occurrences. The total present value of cost-savings in commercial and public buildings from this aspect of the proposals are estimated at £200 million over fifty years.

38 Work done in managing the presence of asbestos will also reduce work that is carried out under existing legislation when a building is demolished. A further (and more detailed) survey would still have to be undertaken, but the sample survey would reduce the scale of this final survey. Some asbestos may also have already been removed from the building as part of the management strategy. Since it may be some time before the building is demolished, these

costs savings are very sensitive to discounting. Taken together they amount to £319 million in undiscounted terms in commercial buildings, but total £90 million in present values.

BUSINESS SECTORS AFFECTED

39 All business sectors will be affected by the proposals, except self-employed workers (and other such groups) who do not work from fixed premises. These groups will benefit through risk management systems, but not incur any direct cost. Building contractors, and those undertaking work likely to disturb asbestos will be also be affected.

TOTAL COMPLIANCE COSTS

40 Total undiscounted costs to all non-residential sectors are estimated at £1.8 billion in total over 2000-2050. This is equivalent to £1.4 billion in present (year 2000) values, since much of the cost is recurring in nature. Costs are summarised in the following three tables.

Table 1: Total compliance costs of duty to manage, by type of building

Building Type	Initial cost (£m)	Recurring cost (£m/year)	Net present value (£m)
Retail/Industrial	905	7	871
Agriculture	196	0.7	180
Education	56	1	58
Hospitals	24	0.5	27
Other Healthcare	31	0.5	34
State	24	0.3	26
Public	132	2.3	146
Places of worship	26	0.4	29
Total	1396	13	1372
TOTAL NET PRESENT COST	**1,372**		

Table 2: Total compliance costs of duty to manage, by nature of cost

Nature of cost	**Compliance costs (£m)**	**Net present value (£m)**
Familiarisation	33	33
Initial desk work	46	45
Survey	597	523
Remediation	642	561
Management (initial)	76	67
Management (per year)	13	142
Total		**1,372**

Table 3: Initial cost of compliance - total cost per building type

Building type	Admin costs (£m)	Survey costs (£m)	Remediation costs (£m)	Management system costs (£m)	Total cost per building type (£m)
*Retail/ Industrial	48	402	401	55	905
Agriculture	11	39	143	4	196
Education	5	20	29	2	56
Hospitals	2	8	13	2	24
Other Healthcare	1	19	10	2	31
State	2	13	7	2	24
Public	10	78	36	8	132
Places of worship	2	18	4	2	26
Total (£m)	1396				

* The figures in this category are aggregates for the four building types (factories, offices, shops/resturants, warehouses/workshops) in the retail/industrial sector.

41 Total initial costs are estimated at £1.4 billion, around 65% of which will be incurred by the retail/industrial sector. This is an undiscounted figure, and it is not the same as the £1.4 billion discounted cost above (even initial costs are discounted, as they are incurred over several years). These large initial costs are due to the wide-ranging nature of the proposals, and should be placed in the context of total construction activity in GB. For example, in the year 2000, total construction activity in repair and maintenance (except private dwellings) was just over £18 billion.

42 These initial costs would not be incurred in the first year, but spread over several years (this is detailed in Annex C). Spread over five years, the initial costs (around £300 million each year) would be around 2% of the total spend on repair and maintenance each year.

Costs to a typical business

43 We previously supplied unit costs over all buildings requiring at least some action. However, since management costs vary so widely, these were not informative. We now give a range of examples for buildings of varying sizes and containing asbestos in varying amounts. In these estimates, we cannot differentiate in costs between different types of asbestos. However, our removal costs are based on out-turn cost data, which will reflect the mix of asbestos types that are encountered in practice. The examples are specified as follows, and costs are described in the table immediately below:

Example 1: A medium size factory premises (2,500 m^2 in total). A specialist surveyor identifies asbestos present in typical amounts, much in poor condition. A decision is made to totally remove the asbestos.

Example 2: A large warehouse (10,000 m^2). A specialist survey finds asbestos in typical amounts, but in generally good condition. This is managed rather than totally removed, although a small proportion is removed.

Example 3: A small shop, (200 m^2 including store-room). An initial walk-through by the owner finds no obvious risk, even if there was some asbestos present. However, before some renovation work five years later, an asbestos survey is carried out. No asbestos is found.

Example 4: A large 1960's office block (50,000 m^2). A specialist surveyor identifies asbestos present in typical amounts, but in good condition. Rather than remove this, an on-going system is set up to manage the risk.

44 Our estimates of the costs under these scenarios is as follows. The total costs are intended to be averages rather than maximums, and relate directly to the size of the building in question (this is on a proportional basis within building types, but not between building types). In some of the examples, there will be some small recurring costs for ongoing management. These are estimated to be no more than 10% of the initial management system costs (excluding removal). For the office, we estimate they would be around £700 per year.

Table 4: Predicted costs of the proposals to the above examples

	Familiarisation; desk research; walkthrough	Specialist survey	Management (incl. removal)	**TOTAL**
Example 1 (Factory)	£450	£1,400	£90,000	£92,000
Example 2 (Warehouse)	£420	£1,400	£11,500	£13,000
Example 3 (Shop)	£11	£420		£430
Example 4 (Office)	£2,800	£19,000	£7,000	£29,000

Duties for those carrying out building work

45 We have examined the cost of the new duties for those carrying out work likely to disturb ACM. These are estimated to be £14 million per year initially, of which around £6 million relates to commercial premises. Costs fall as buildings are demolished, so that total

net present costs are £200 million and £80 million respectively. Details of the calculations are in Annex C below.

Costs of accreditation for bulk analysis

46 Also in Annex C, we estimate that the requirement for any laboratory engaged in the analysis of materials to identify whether or not they contain asbestos to be accredited by an appropriate body complying with international standards will cost between £100,000 and £160,000 each year over the first five years, with falling costs after ten years. For the thirty-five new laboratories, and fifteen existing laboratories, that we estimate may become newly accredited, this would lead to costs over fifty years of £1.8 million in present terms.

Costs of proposals in common areas of residential accommodation

47 The common areas of rented residential premises will be under the scope of these proposals. These are not included in the costs estimates given above (which relate solely to commercial premises), since we cannot estimate the benefits in common areas. The total costs and benefits of applying the proposals to the residential sector are examined in a separate document. This further work currently estimates that the costs of the proposals for rented residential accommodation as a whole are £1.6 billion, including full compliance with existing regulation. This compares with benefits of £1.8 billion.

48 We previously lacked sufficient information to separate costs in common areas from total housing costs. We have now pursued this further. In particular, we have received information on the proportion of common floorspace from a major demolition company dealing with the removal of asbestos from residential accommodation. We estimate that the total costs of the proposals as they apply to common areas will be £200 million over 2000-2050. This is equivalent to around £110 million in present values, since much of the cost will not be incurred immediately.

49 As already mentioned, we cannot separate the benefits of the housing proposals into the proportion relating to common areas. However, rented accommodation with common areas are more likely to be purpose built flats, than (for example) houses. These flats are more likely to have been built during the periods when asbestos was widely installed, and also are more likely to be `system built' in any case. The cost benefit balance is therefore likely to be more favourable than the overall balance in the residential sector. Some one-fifth of all housing units are either in a residential block or in a converted house, and therefore likely to have a common area. The overall effect on the balance of costs and benefits in the commercial sector will not be great, indeed if the common area costs were to be included in the cost-benefit balance, then we believe the effect would be to increase overall benefits slightly more than overall costs.

Impact on small and medium sized businesses

50 There is likely to be some disproportionate impact on those businesses who operate from small premises, or who have a number of small premises at different sites. This arises through minimum `call-out' charges that will be incurred if the premises specialist surveyors are employed, and effectively sets a minimum charge for surveying any premises (of around £250 in these estimates).

51 However, a number of factors will tend to limit this disproportionate impact on SMEs. Firstly, those in small premises are more likely to be familiar with the layout of their buildings and where any asbestos might be present, and be able to take up the flexibility offered by the ACoP. Secondly, many SMEs will actually work from relatively large premises, and would not be subject to minimum charges (surveying costs would be higher for larger premises, but not disproportionately so). Finally, many SMEs will work from premises which form a unit of a larger building. These SMEs could very well experience relative savings if the work is undertaken by the building managers for a number of units on the site.

52 To confirm this view, we contacted seven small businesses that may be affected by the introduction of the duty to manage. These firms were split evenly between manufacturing and service sectors and occupied premises with areas from $80m^2$ (small shop) to over $1000m^2$ (factory and office complex). One firm had previously commissioned a specialist 'building survey' of their premises, which did not discover any asbestos. Two other firms stated that they were aware of ACM present in their workplace and that due to the type/structure of their premises they were sure that there was no other asbestos present other than the materials they had identified.

53 Management was seen by most respondents as being a relatively simple affair in small premises. The two firms that were aware of ACM present claimed to operate simple management systems. However, one of these respondents who had an asbestos cement roof indicated that if the asbestos present was found to constitute a risk requiring the removal of the roof, this would involve a significant business expense. All firms contacted were either indifferent about or in favour of the proposals.

Costs to government

54 These costs will include the costs to local authorities concerning public buildings, costs to central government in grants for the administration of schools, hospitals and other healthcare facilities, and also costs to central government concerning buildings directly administered by the state (regardless of whether these may be managed by the private sector).

55 The data on the number of premises of various types provides an indication of the proportion of costs that will fall on the public sector. For example, our data on number of premises distinguishes between state and private schools. We are unable to separate costs relating to public buildings and government offices between central and local government because they may be administered by either body (for example public libraries versus local benefit offices).

56 We estimate that some £140 million of the initial undiscounted costs of £1.4 billion at table 1 is likely to be born by the public sector. The costs in common areas of residential accommodation would add some £50 million to this figure, giving a total of around £190 million. This represents the expenditure from public funds over the period when surveys are likely to be undertaken, in the first five years following the introduction of the proposals.

Costs of Enforcement

57 The enforcement of these proposals will be considered as part of a review of the Enforcing Authority regulations which will take place later this year. The costs of

enforcement will be considered separately at this time. In advance of these considerations, we recognise that there will be an increase in the overall enforcement effort associated with the Control of Asbestos at Work regulations, but that it will be relatively small compared with the costs of compliance, or the total benefits of the regulations.

58 We have now conducted a preliminary assessment of enforcement costs. We estimate that training in the requirements of the amended regualtions will take an average of two days time per inspector. For LA inspectors we apply this cost to each full time equivalent inspector, while for HSE we apply it to 75% of the 1,500 members of Field Operations Directorate (FOD). This gives a total one-off cost of training of just under £1 million.

59 HSE and LA inspectors conducted a total of around 370,000 inspections in the year 1999/2000. We assume that initially the enforcement of these regulations will add *on average* 40 minutes extra to average inspection time, for 60% of these inspections. This leads to an intial cost of £4.0 million a year. We further assume that this yearly cost declines gradually to half of this amount after five years. as inspectors and employers become increasingly conversant with the regulations and increasing numbers of buildings are surveyed and found not to contain ACM.

60 On this basis enforcement costs are estimated at £5 million in the first year the proposals come into force. Total enforcement costs over ten years are estimated at £23 million in present value terms.

Costs to HSE

61 Costs to HSE, in developing and publishing the regulations and ACoP, are expected to be relatively small, and these costs can mostly be considered as `sunk'. Costs to HSE of enforcement are expected to be around £3 million, of the total estimated above, in the first year that the proposals. Total enforcement costs to HSE are estimated to be around £15 million over a ten year period in present values. These estimates are subject to change following the outcome of the review of the Enforcing Authority regulations, expected to take place in late 2002.

Total costs to society

62 The total costs of this package of regulations are shown in the table below. When considering the comparison between costs and benefits in the commercial sector below, we exclude those costs relating to the residential sector. Total costs to society of this package of regulations are estimated at £1.7 billion.

Table 5: Total costs of package of regulations (£m - present values)

Sector	Element of cost	Total present value cost (£m)
Commercial sector	Duty to manage	1,372
	CAD related costs	80
	Accreditation costs	2
	Enforcement	23
Residential sector	Duty to manage in common areas	110
	CAD related costs	120
Total costs of this package of regulations		**1,707**

ENVIRONMENTAL IMPACTS

63 A widespread duty to identify and manage asbestos would result in increased levels of disposal compared to current levels. The costs of disposal were estimated at £40 million for around 1.1 million tons of ACM and associated material (including wetted material) from workplaces. Spread over the time period the disposal would take place, this would represent an increase of around 30% of the amount of asbestos disposed compared to currently. A full discussion is at Annex C.

COMPARISON OF COSTS AND BENEFITS

64 The costs of the various options for dealing with asbestos in commercial premises are displayed in the table below. We include the cost of the new duties under the Chemical Agents Directive, which these proposals also implement. These are estimated at £200 million over fifty years, discounted to present values, of which £80 million applies to duties in commercial and public buildings. Accreditation will cost a further £1.8 million. The costs of the 'ACoP approach' in commercial buildings are therefore estimated at £1.5 billion over fifty years in present value terms.

Table 5: Summary of costs in commercial and public buildings, including CAD duties, accreditation of bulk analysis and enforcement

Description	**Option number**	**Present costs (£m, discounted)**
ACoP approach to surveying and management.	a	1,468
'Do nothing' except implement CAD duties.	b	[see below]

65 By comparison, the estimated safety benefits of the duty to identify and manage asbestos, when coupled with full compliance with other regulation, are valued at £3.0 billion, together with cost-savings of £290 million, giving total benefits of £3.3 billion.

Total costs and benefits of eliminating exposure to asbestos

66 Before a comparison of overall costs and benefits can be made, we first recognise that in order to weigh costs against a full elimination of the risk, we have to assume full compliance with both existing regulation, and also proposed future changes that are likely to come about as a result of any tightening of this legislation, in particular under the Asbestos Worker Protection Directive.

67 The costs of full compliance with the Directive (much of which is already present in UK law) has been examined as part of regulatory impact assessment prepared for a proposed revision of the Directive. Costs were prepared on the basis of both the existing control limit, and also a tighter control limit, of 0.1 f/ml for all forms of asbestos. Regardless of whether the new control limit is adopted, it seems prudent to include these costs when judging against total elimination of risk.

68 Total costs of a tighter control limit, coupled with full compliance with each element of the Directive, are estimated at just over £1.9 billion over fifty years in present terms. Of this, the vast majority of cost is due to full compliance with provisions that are already in UK law. The principal costs are from adequate training for *anyone* likely to disturb asbestos as part of their work, adequate control measures - including personal protective equipment - if asbestos is encountered being fully implemented/used, and ongoing medical surveillance for workers with more frequent exposures over the entire period.

69 In practice we would expect that it would be difficult to gain compliance with the elements of the directive related to controlling exposure in the residential sectors. Maintenance workers would be far less likely to routinely take precautions, such as temporary encapsulation, without knowledge of whether asbestos was present where they were working. This is known to be one reason why compliance with current control related requirements is less than full. Undertaking control measures on the off-chance that asbestos is present is far less cost effective than if the presence and location is known, and this represents a real barrier to compliance with existing regulations.

70 However, we do assume full compliance with existing and proposed training requirements as any maintenance worker may work at sometime on commercial or public property. When calculating the costs of fully eliminating the risks in commercial and public buildings we therefore include the costs of control in these sectors and the full cost of training for all maintenance workers. The total cost of these two elements of the directive is estimated at £1.6 billion of the £1.9 billion total costs of the directive.

Option a

71 The total costs of fully eliminating the risk in commercial premises are therefore estimated at just over £3.0 billion over fifty years, compared to benefits valued at £3.3 billion. Benefits are subject to the considerable uncertainties described, although we believe we have made a reasonable estimate. Given this, we therefore believe application of both CAD and the duty to manage risks is justified on a cost-benefit basis.

Option b

72 The costs of implementing CAD in the commercial sector, with the management proposals in place, is estimated at £80 million. However, in the absence of the management proposals we believe that the CAD related costs would be far higher. In many cases, maintenance workers will not know if any ACM is present, or it's actual location if it is thought to be present. This must affect the risk assessment they would be required to do. In the absence of a preceding survey, the time taken to establish the presence, or not, of asbestos and any subsequent amendments to the workers' risk assessment may be considerable (at least in some cases). This argues that the cost of implementing CAD in the absence of any other management action could be at least double the calculated cost, ie in the order of £160 million.

Uncertainties

73 In the conclusions above we have used HSE's best estimates of costs and benefits. As the benefits section makes clear, there is considerable uncertainty surrounding our estimate of future risk of exposure to asbestos. This is particularly the case with respect to the extrapolation of risk to generally low levels of exposure. The uncertainty surrounds both a basic choice about which dose response relationship is true for the low levels of exposure we are modelling (compared to the exposure levels giving rise to observed mortality), as well as uncertainty around the estimates that each of these choices would produce. Given this, we cannot present a plausible range of estimates around a central figure. This is discussed in detail in the benefits section below.

74 With respect to costs, we believe that we now have accurate data on numbers of buildings and the unit costs of different surveying and management approaches. The principal uncertainties surround the percentages of buildings that have already had ACM removed, or have an adequate management system (under the ACoP) in place, and also in the type of action that may be taken in the remainder of buildings. However, we believe our estimates represent the best *central* estimate of costs.

75 With respect to the *balance of costs and benefits*, another important sensitivity arises from the use of discounting. The long lag between fatal exposure and death, particularly for mesothelioma, means that the effect of discounting benefits is severe. The discount rate for benefits, of 2%, reflects individual's observed weighting for benefit this year rather than the same benefit next year. The same weighting (this time a *disbenefit*) is included in the rate of 6% for discounting costs.

76 If this 'pure time-preference' weighting is reduced to, say, 1.5%, then the best estimate of benefits is increased to £4.3 billion in present values from £3.3 billion, so that benefits now exceed costs by £1.3 billion. HM treasury recommends that a time preference discount rate is used, but states that there is some uncertainty over it's amount, with figures of between 1% and 2% suggested. It should be noted that the value HSE (in common with DfT) uses for discounting benefits lies at the top of the suggested range. The Department of Health uses a figure of 1.5%.

77 The benefit figures are also sensitive to the doubling of the DfT's value attached to the reduced risk of a future fatality. At standard valuations, benefits would be just over

one-half the value shown (cost-savings would not change). The overall conclusions are therefore sensitive to this assumption. The DfT value is based on research identifying the amount individuals would be willing to pay to avoid a small future risk. Because of the dread associated with contracting cancer, and the fact that this illness is almost always associated with a long period of suffering, we believe a substantial upwards adjustment to the DfT value is justified.

Arrangements for monitoring and evaluation

78 These are significant proposals, and HSE intends to conduct a thorough evaluation at the appropriate time.

HSE Safety and Health Economics

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ANNEX A : RISK ASSESSMENT

MODELLING PAST AND PRESENT RISK

Introduction

A1 All forms of asbestos are classified by the European Union as category 1 carcinogens. It has long been accepted that the risk from exposure to amphiboles (amosite and crocidolite) exceeds that from exposure to chrysotile. Nevertheless HSC's policy (and that of the European Union) has been that exposure to all forms of asbestos should be prevented, or exposure minimised where prevention is not reasonably practicable.

A2 The main human health effects associated with occupational exposure to asbestos are fibrosis (asbestosis), lung cancer and mesothelioma. Evidence that asbestos is associated with an increased risk of cancer at other sites is inconclusive.

A3 Health risks can be considered in two groups, namely workers disturbing asbestos containing materials and other individuals, including members of the public, who may be affected by these work activities or the presence of disturbed or degraded asbestos within buildings they inhabit or visit.

Approach taken in modelling past and future risk from asbestos

A4 We have both further refined and also extended our modelling of previous and current asbestos mortality. The calculation of potential lives saved from the duty to manage regulations involves a number of steps. These are as follows:

Step 1. Model the link between exposure and mesothelioma deaths at the population level.

Step 2. Estimate current exposure levels.

Step 3. Calibrate the risk generated by estimated current levels to the exposure index in population model

Step 4. Estimate how this current level of population exposure would change over the next 50 years if no additional control action was taken.

Step 5. Use the model derived in Step 1 to predict the number of deaths over the next century which would be produced by the future exposure profile estimated in Step 4.

Step 6. Partition these assumed deaths into those due to asbestos in commercial buildings and those in domestic buildings.

Modelling the link between exposure and mesothelioma deaths at the population level (step 1)

A5 The basic approach here has been to infer the past track of asbestos exposure from year to year from the detailed pattern of male mesotheliomas by age and year (the data is single years, and single years of age to age 89). This approach assumes that the population's total exposure to asbestos can be summarised in each year by a single number, and that the relationship between this summarised exposure index and future deaths from mesothelioma will take the same form as is widely assumed for the relationship between asbestos exposure and mesothelioma risk at the individual level:

$$r = CD(t-10)^k$$

A6 Here, r is mesothelioma risk at time t; D is cumulative exposure; t is time in years since exposure and C and k are parameters to be estimated. In the individual level equation, k takes values around 2 or 3.

A7 When expressed at the population level further factors need to be built into the equation to reflect the age distribution of exposure. We also included terms to model a possible trend in the completeness of diagnosis, and of clearance of asbestos fibres from the lung.

A8 Table 1 shows the parameter values taken by the best fitting model without a term to represent clearance of asbestos from the lungs. The fit is surprisingly good, given the simplifications inherent in this model. The model has an overall deviance is 220.6 (on 182 degrees of freedom). Visually (see figure 1 at **Appendix 2**) the fits by age, time and cohort also look close; and the two-dimensional display of deviance residuals by five year age and cohort groupings also shows a reasonably uniform pattern with no strong clustering of residuals of the same sign (for clarity, the positive and negative residuals are plotted in separate charts) - although two birth cohorts (births in 1923-27 and 1938-42) show levels consistently above predicted levels, and the observed numbers at ages 80 to 89 are generally lower than predicted.

A9 The value estimated for k is 2.6, in the middle of the range expected *a priori*. The maximum year for exposure is estimated at 1967, with a very steep (but poorly determined) reduction in exposure after this date.

A10 The estimates of relative exposure potential at different ages imply that exposure is concentrated on the age group 20 to 49. Higher age groups are estimated by the model to have a zero exposure weight, but this is due to the lag from exposure to effect, which means that these parameters have only a small influence on the fit. Of more interest is the fact that the weight for exposure between the ages of 16 and 19 is estimated at less than a third of exposure at adult ages, and that exposure from ages 5 to 15 is estimated very much lower still (less than 3% of adult level). These estimates support the conclusion drawn from other evidence (e.g. the comparison between male and female rates) that it is occupations, especially male occupations, that provide the main source of exposures.

A11 The diagnostic trend term in the model is estimated at 5% (ie that the number of undiagnosed cases occurring decreases by 5% per year). We have assumed that diagnosis was effectively completed at an arbitrarily chosen 98% in 1997. The estimate of 5% trend implies that in 1968, the start of our data series, diagnosis was about 90% complete. This seems a reasonably plausible conclusion. It has a only a minor effect on the model.

Table A1: Fitted parameters for main model (no clearance)

Measures of fit			
Deviance	220.10	(on 186 degrees of freedom)	
Serial correlation (time)	0.29		
Serial correlation (cohort)	0.38		
Durbin-Watson	1.27		
Parameter estimates			
k	2.6	Diagnostic trend (decrease in cases missed - % per year)	5
Maximum exposure year	1967		
Change in exposure index (%per year) in...		Relative exposure potential by age group	
1922	33	5 to 15	0.03
1932	5	16 to 19	0.29
1942	11	20 to 29	1
1952	9	30 to 39	1.38
1962	5	40 to 49	1.08
1967	0 (by def)	50 to 59	0
1972	-16	60 to 69	0
1982	-72	70 to 79	0

A12 A fit quite similar to the one described in table A1 can be achieved by setting the maximum exposure five years earlier, increasing k to 3.8, and setting the clearance half life at 15 years. The overall fit for this clearance model is only slightly worse than for the table A1 model (it's deviance is 225.6) but the fit to recent data is worse. For cohorts born since 1948 the clearance model predicts a total 285 deaths, instead of the 251 observed the (a statistically significant difference, p =0.042), and the fit to the last two years of data is poor with predicted totals for 1998 and 1999 of 1243 and 1283, compared to the1309 and 1361 observed. We therefore adopt the non-clearance model as the basis for the predictions.

A13 A large (and increasing) proportion of the predicted future deaths are at ages 80 and above. This is driven both by the form of the model, and by the increasing survival to older ages in the population. Although the mesothelioma model used here fits observed mortality in occupational cohort studies quite well, it can reasonably be doubted whether the risk of mesothelioma increases indefinitely with time after exposure. The few occupational cohorts with very long follow-up all show eventual falls in mesothelioma rate. For this reason previous risk assessments have truncated their predictions at age 80. Clearly this is an approximation since there will be at least some deaths at ages 80 and over. Therefore, the population model fitted here has included deaths up to age 89. As noted above, there is some indication that the fit is less satisfactory at ages 80 and over. For the purposes of mortality prediction we will limit these to deaths below age 80, though we note that this is likely to be an under estimate. The true value will lie somewhere between this total and the total predicted including deaths to age 89.

A14 Comparison of the estimated track of exposure with the figures for imports of asbestos of various types suggests that the amphibole component of imports was a much more important determinant of mesothelioma mortality than that of chrysotile. Figure 2 shows the profile of asbestos imports along with the fitted exposure index. None of the import series reflect the exposure index profile very closely, but the timing of the fall in exposure corresponds quite closely with that for amosite imports. Chrysotile imports did not fall until about ten years later. If chrysotile was a major determinant of mesothelioma mortality, the fitted exposure index should show a later fall.

Estimating the fall in previous exposure levels

A15 If the rate of decline in the 10 years following the implied exposure peak had continued, exposure levels would have fallen to essentially trivial levels well before the year 2000. But there is no real basis for assuming this rate of decline will have continued. Its main driver will have been the rapid reduction in initial processing of imported fibre into asbestos products and their installation. Once exposure has fallen to the level generated by continued routine building maintenance and demolition (and asbestos removal), the rate of total population exposure would be expected to be fairly constant. We have no good measurement-based evidence for knowing what this level is.

A16 Although we can be confident that total exposure fell rapidly in the ten years or so following the peak of exposure, the statistical uncertainty about the course of exposure grows rapidly from around the mid 1970s. We can assess how far we can be reasonably confident (on the basis of this direct evidence) that exposure has fallen by examining the impact on the model fit of levelling off the assumed exposure at different points on its downward track. Table 2 records the effect on the overall fit and on the fit for cohorts from 1948, of levelling off exposure from different years in the the 1970s. The reason for looking separately at more recent cohorts is that they constitute the most critical group for future deaths. If the model fits these cohorts poorly, it is unlikely to be a reliable guide to future levels of mortality.

Table A2: Effect on model fit of levelling off exposure level at different years in the 1970s

	Overall fit		Births since 1948 (251 observed deaths)		
Exposure levelled off in year	Deviance	p value for equivalence to best fit	Predicted deaths	p value for observed number given predicted level	Exposure index from cutoff (% of max year index)
1972	275.3	p<0.001	359.9	p<0.001	71%
1973	255.6	p<0.001	337.1	p<0.001	60%
1974	239.7	p<0.001	314.9	p<0.001	47%
1975	229.1	0.004	296.6	0.004	34%
1976	223.4	0.065	283.5	0.033	23%
1977	221	0.33	275.3	0.074	14%
1978	220.2	p>0.5	270.8	0.12	8%
1979	220	p>0.5	268.6	0.15	4%
1980	220	p>0.5	267.8	0.16	2%

A17 Levelling off in 1975 or earlier is clearly inconsistent with the observed mortality. In 1976 the overall fit is just acceptable, but that for men born since 1948 is not. A levelling off in 1977 gives a good fit overall and a just acceptable fit for the recent cohorts. This implies that we can be pretty confident that exposure is 14% or less of the peak level. Figure 3 shows the predicted effect of levelling off at 1977's exposure level. For the purposes of projecting mortality levels in the future the current and future path of exposure is the crucial assumption. This is described in the following major section.

CURRENT EXPOSURE TO ASBESTOS (step 2 in modelling procedure)

Introduction

A18 The modelling outlined in the last section tells us that the peak of asbestos exposure occured in the 1960s, and that exposures have fallen substantially since then. Since there is a lag between asbestos exposure and the occurrence of mesothelioma, the strength of the inferences that can be drawn about exposure levels falls quite rapidly towards the end of the observation period, and our observations of mortality (currently up to 2000) tell us nothing (directly) about exposure levels since 1980.

A19 However, the evidence at Appendix 1 [the HSL report] is that this has not in fact happened. There are still large quantities of asbestos in place in buildings, and a large number of people are potentially exposed in one way or other to fibres generated by this material. In order to estimate current risk, we therefore need to estimate the level of current exposures and, using the risk coefficients published in a recent paper in the Annals of Occupational Hygiene[1], calculates the effect of long term exposure at these assumed levels in terms of annual mesothelioma mortality.

A20 The calculated long term mortality implied by the continuation of current exposures can then be used to identify the corresponding current level of the exposure index generated in the projection model. In other words, the exposure index is set to the level that produces the same projected long-term mortality. The estimate of long-term mortality for different future trends from present levels can then be calculated. We assume that exposures reduce from current levels in proportion to the projected removal of asbestos materials.

A21 The proposals aim to address remaining risks so that preventative measures can be taken to avoid inadvertent exposure, which is likely to be a significant factor for previous generations as well as future ones. Beyond correcting for building demolition, we do not allow for any further reduction in risks beyond that indicated by current exposure, since we are estimating the total costs and benefits of managing all risks from asbestos present at this time. Any future actions (other than demolition) which would have been taken in the absence of these proposals will reduce the costs and benefits *attributable to the proposals*, but this would not, in itself, change the balance between costs and benefits. We are therefore calculating the benefits of any action taken to minimise exposure, including full compliance with current regulation. The `baseline' of estimation is discussed in more detail at the front of this report.

Current exposure

A22 The number of people who are being exposed to asbestos in current conditions, and to what levels is difficult to judge. Past evidence suggests that exposure has been widespread among the male population but less so among women. Certain occupations, in shipbuilding, railways and in building related work (including some industrial jobs) have recorded very marked excesses of mesothelioma. These jobs have represented nearly 25% of the male

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1. Hodgson JT and Darnton A (2000) The quantitative risks of mesothelioma and lung cancer in relation to asbestos exposure. Ann. Occup. Hyg. 44: 565-601

population, of which 20% are building-related and industrial. But outside these clearly high risk groups there is a large number of individuals with moderately raised risk. This pattern corresponds to our knowledge that the use of asbestos products in insulation and building materials is also very widespread.

A23 One of the problems in estimating actual exposure is that it is the episodes of unwitting exposure that are of key importance, and it is these exposures that the proposed duty to manage is particularly targetting. But, almost by definition, such exposures cannot be observed - except, perhaps, by indirect methods (for example by widespread use of passive sampling; or from observation of lung content of asbestos in the general population). The potential impact of occasional excursions on exposure means that average background levels are an uncertain guide, and have a clear potential to underestimate actually occurring exposures. Most exposure above the background level will be delivered in short term excursions, not as exposure to consistent levels. Short term excursions can rapidly and very significantly raise average levels for the day.

A24 Table 3 (in the summary below) shows our estimates of the percentage and numbers exposed on a typical working day at ten exposure levels from 0.00001 f/ml to 10 f/ml. It should be noted that the `exposure level' represents the mean exposure for the identified group. There will, in each case, be a distribution around this mean.

A25 We distinguish seven activity categories: asbestos removal, demolition, regularly exposed building/maintenance work, other building/maintenance work, other occupational exposure and non-occupational exposure (treating exposures below age 20 and from 20 up separately). The exposure distributions are also shown in cumulative percentage terms in figure 4. We take the group `building/maintenance' workers to cover all building-related occupations, including architects, building inspectors, civil engineers and some industrial maintenance jobs.

Highly exposed groups

A26 One group of workers with a clear potential for high exposures is, of course, asbestos removal workers. Although such work should be done in such a way as to minimise exposure, and with the use of efficient RPE, it is inevitable that there will be some failures in the chain of control. In this setting, when precautions do break down, very high exposures may quite readily be incurred.

A27 Demolition workers will also have potential exposure to asbestos materials, sometimes at quite high levels. Such materials should be identified and removed before demolition takes place, but again we can expect that this will not be fully effective (particularly in the absence of an explicit duty to manage asbestos). In these cases the workers will not be aware of the presence of asbestos and will be exposed without any kind of protection. We estimate that these two groups of workers, once the controlling action taken by removal workers is accounted for, will have similar exposure distributions.

A28 Apart from asbestos removal workers and demolition workers there is a moderately large group of workers who will regularly come across asbestos. This group will be drawn mainly from certain building related trades - carpenters, electricians, plumbers and gas fitters - but also from maintenance engineers on industrial plant. These are broadly the same jobs who were exposed when these materials were first installed. The standard occupational coding scheme, while giving some guidance on the numbers with potential exposure, does not give a precise guide. Some individuals, even in the most exposed categories, will have little exposure, and some from groups with in general little exposure potential will work in ways - or in settings - which may give them exposures similar to some of the more highly exposed groups. This group with regular asbestos exposure may reach similar exposure levels as demolition workers.

A29 At around 1 f/ml and above the main contributors to exposure are found in the regularly exposed group with a smaller number coming from other building workers. We estimate a total of approaching 5000 individuals on average could be found on on a working day with a daily TWA exposure of 1 f/ml and higher. The size of the regularly exposed group is discussed immediately below.

Intermediate exposure

A30 In the exposure ranges centred on 0.01 f/ml up to 0.05 f/ml we estimate there are just over 900,000 individuals: 150,000 at around 0.05 f/ml; 68,000 at around 0.1 f/ml; and 16,000 at around 0.5 f/ml. At the two levels spanning the current control limit (0.1f/ml and 0.5f/ml), we assume exposure is found in roughly equal numbers among the regularly exposed and among other building workers (who meet these levels less frequently, but of whom there is a larger number).

A31 We define regularly exposed workers as those working with ACM for more than one-tenth of their total working time. Our estimate of the total size of this group, 240,000, or 13% of all building and maintenance workers, is based on a judgement of which particular trades will be most at risk from asbestos and what proportions of all workers in these trades this regularly exposed group will account for. Detailed occupational information was obtained from the Labour Force Survey. Trades falling in this group include electricians, heating engineers, fitters, and some carpenters and joiners. In addition, we tried to account for activities not identified by the standard coding, such as `cable-pulling'.

A32 We estimate some 20% of this group will be exposed at levels centering on 0.01 f/ml and also a further 20% centering on 0.05 f/ml (and a further 15% at still higher levels). This distribution comes from information contained in the HSL report. For example, exposures of 0.5 f/ml and above are noted in many studies for a minority of workers, and this would translate into a long term (or typical daily) level of 0.05 f/ml. For those in regular contact with asbestos, a long term level centering on 0.01 f/ml translates into an exposure of 0.1 f/ml during their contact time. We believe this is entirely reasonable for this group, but we emphasise this is only a small proportion of all building workers taken together.

A33 At exposures centering on 0.05f/ml most of these individuals come from the other building/maintenance workers, but with a significant contribution (13,000) from the remainder of the working population. Exposures at this level can be thought of to principally come from infrequent and largely inadvertent exposure at very high levels to groups of workers whose job is such that they may be bought into close contact with asbestos.

A34 Other building/maintenance jobs will also carry a higher level of potential asbestos exposure than the broad generality of jobs. When these materials were being installed, (and setting aside the specialist settings of shipbuilding, railways and asbestos manufacturing) something like 20 percent of the male workforce was sufficiently exposed to raise their mesothelioma risk at least four-fold from background levels. The 1.0 million we have assigned to moderate exposure in current conditions represents about one-third of this level.

A35 We estimate that around 10% of building and maintenance workers will be exposed around the level of 0.01 f/ml, and a further 10% at higher levels. We believe that this relatively high level of exposure compared to the group as a whole will arise both from a relatively high exposure during contact, coupled with (but to probably a lesser extent) a higher frequency of contact. A level of 0.01 is consistent with a 4 hr TWA average exposure of 0.2 f/ml for one-twentieth of working time. As the HSL report notes, episodic exposures of this level or above are reported for maintenance workers both in the US and the UK *when the material is known to be asbestos,* and at least some action is being taken to prevent exposure. As with the regularly exposed workers, the distribution must also take into account those occasions of inadvertent exposure - although at a lower frequency. Inadvertent exposure could easily give a 4 hr TWA exposure of between 1 and 10 f/ml.

A36 The distribution of exposure for this key group also depends crucially on the frequency of exposure. We have defined this group to be ‘occasionally exposed’, and it is composed of the vast majority of all building and maintenance trades. We make a base assumption that this higher exposed sub-group is exposed to asbestos at a frequency of 5% of their working time or above. This higher frequency of exposure will arise both through the nature of the particular task undertaken, and also if these workers work more often in asbestos containing buildings.

A37 This is a higher frequency than we would expect on average for all building workers in buildings containing asbestos. There is very little research on the frequency of exposure, however some evidence has been collected from the US. The study by Corn et al cited in the HSL report explicitly collected overall frequencies of exposures for work on spray applied ACM ceilings in five separate buildings. The report noted that “Individual maintenance personnel in the five buildings investigated worked above the ceilings and were in proximity to spray applied [asbestos] fireproofing for less than a maximum of 5 per cent of their total working time [during the study period of between 4 and 8 months]”. The percentage of working time exposed typically varied between 0.5% and 3.5%, with most figures between 0.5% and 1%.

A38 However, this study focused exclusively on one type of asbestos and at one location. There may be many locations other than the ceiling which contain asbestos, and these may well be accessed more frequently during routine maintenance. In addition, the buildings studied had occupational health management strategies in place, which we can assume included minimising contact where possible. Conversely, controlling and measuring the exposures may have inflated the exposure times above the levels that would have taken place in the absence of the study, although the first effect - the need to limit exposure time - is likely to be the more important influence.

A39 We believe a reasonable assumption for the frequency of contact of all building workers working in buildings containing asbestos is around 2.5% of their total working time, on a 4 hr period basis. This is equivalent to roughly twelve 4 hour working periods per year, or six working days. The 10% of maintenance workers that we assume are exposed at 0.01 f/ml are therefore exposed to asbestos twice as frequently as the assumed average for maintenance workers in ACM containing buildings. Furthermore, the 5% of other building workers exposed at around 0.05 f/ml can be thought of to be incurring exposures of 0.5 f/ml for 10% of their working time. At the other end of this scale, we will also have many maintenance workers working in non-ACM buildings who hardly ever (or never) come across asbestos at all. We estimate that around one-third of commercial buildings contain asbestos. This provides a guide to the numbers of workers more highly exposed compared to those rarely (or never) exposed, although many workers will work at different locations. In fact, we assume around half of all this group is very rarely or never exposed, and we allocate these workers to what can be termed `background' levels of exposure (or at least levels commensurate with no more than very occasional and minor distubance of asbestos material). As described below, these very low levels of exposure are then excluded from our best estimate.

A40 Finally, we have assumed some one-half million other workers are exposed at a long term (or typical daily) level of 0.01 f/ml, with a very few (some 14,000) above this level. This represents 2% of all persons in work. This is more exposure in total than amongst building workers at this level, which may seem surprising. However, this exposure arises from three important sources.

A41 Firstly, this exposure will arise from incidental exposure following the work done by maintenance and (to some extent) removal workers. We have estimated that a total of some 200,000 maintenance workers are exposed at levels of 0.05 f/ml or above. We believe it is very possible that those present in the immediate vicinity of the work (other than the workers themselves), and also those cleaning up the area after the work (to the extent that this is not done by the workers themselves; and also where fibres are further disturbed, for example by sweeping up) could be exposed to significant levels of asbestos.

A42 A broad estimate of the size of this group can be made from the following assumptions. For every maintenance worker exposed to asbestos whilst working at a commercial premises, we assume that there are a corresponding two persons at the workplace who are exposed to a level of one-tenth the level of the exposed maintenance worker. This would indicate some 400,000 people exposed at a level of at least 0.005 f/ml. In fact maintenance work at a place of work rather than a domestic premises will account for around half of all maintenance work, which suggests that these exposed groups would be split evenly between those at work and those at home.

A43 However, this split depends crucially on the total amounts of asbestos in commercial and residential premises (which we believe to be higher in commercial premises); and also the fact that the higher exposures are more likely to be found in commercial premises since work may be more intrusive than in residential premises. We therefore include most of this group in the `at work' category for simplicity. In any case, this categorisation does not affected the final benefit estimates.

A44 In reality, this type of exposure would be spread amongst far more people (but occurring on a more occasional basis) than the maintenance workers, who will be typically moving from job to job. A more realistic estimate of *long term* exposure to other workers incidental to maintenance worker could well be 4 million at 0.0005 f/ml. In addition, we report below that personal exposure - not at a recently worked area - in buildings with high levels of asbestos can approach 0.001 f/ml.

A45 The group of occupationally exposed workers at 0.01 f/ml can therefore be thought of to be largely composed of the very highest exposures to those workers who work in buildings containing large amounts of asbestos, frequently in poor condition, and where poorly controlled maintenance work is sometimes done. Furthermore, this is the sub-group in close proximity, or likely to further disturb, the asbestos. The majority of even this group will be exposed at a lower level than 0.01 f/ml. This, and an estimate of the overall size of this group, is described immediately below.

A46 Finally, the group of other workers exposed at 0.01 f/ml will include the very highest exposures to non-building workers who disturb asbestos, either through routine work activity, or when carrying out their own maintenance work. Such occupational groups will include warehousemen; store men; farmers; some factory workers; workers in repair shops (especially vehicle repair); and many others. This is a significant group of workers, which could number some three million in total, of which 5%, or 150,000 could be exposed at the highest levels.

Low exposure groups

A47 Personal exposure levels of 0.001 f/ml can be produced by quite minor disturbance of asbestos materials.

A48 In terms of the non-working population, by far the most significant cause of sporadic exposure will be through DIY activity. Using information from time use surveys conducted by the Office of National Statistics, we have estimated that males spend around 1.5 million full-time equivalent years per annum on "Maintenance, odd jobs and DIY". This compares to around 1.8 million full-time paid workers in the maintenance trades, and this rough equivalence appears to be confirmed by the fact that accident numbers in DIY are broadly similar to those in professional maintenance work.

A49 It is therefore clear that DIY activity has the potential to give rise to exposures approaching that of maintenance activity as a whole. Exposure will be lower to the extent that DIY work will tend to be less intrusive, however it is far less likely to be subject to even minimal levels of control. Clearly, it will result in more sporadic exposure than to full-time workers, even if the on-the-job exposure can be as large.

A50 This type of activity is largely outside the scope of any government legislation. Making a basic assumption that the total amount of exposure is roughly equal to that of maintenance workers, but it is spread amongst ten times as many people (at one-tenth of the long-term dose) would suggest some 4 million people exposed at levels of at least 0.01 f/ml. This estimate, in making reference to exposure to maintenance workers, can already be taken to account for the condition of the buildings.

A51 The vast majority of DIY work would be done on owner occupied houses. On the other hand, we know that asbestos will tend to be concentrated in the rented sector. We therefore simply take one-third of this total of 4 million as representative of the numbers of the non-occupationally exposed people exposed through DIY activity in the rented sector, weighted by the amount of asbestos in this sector compared to the owner-occupied sector. None of this risk is under scope of these proposals (since the proposals apply to commercial property), and this is accounted for when we partition risk, as described in the benefit section below.

A52 Another determining factor will be exposures to occupants generated as a consequence of professional maintenance work in their houses. This is reckoned on the same basis as secondary exposure in the occupational setting (see para A42): that the secondary exposure is 1/10 of the exposures to the workmen, but affects twice as many individuals.

A53 About a third of building workers' asbestos exposure takes place in domestic property, we therefore take one-third of the numbers exposed at these levels and reduce the levels by a factor of 10 to estimate the number of domestic occupants affected. We further assume that the two highest exposure levels will not generally occur in domestic properties, and these are accordingly excluded from this estimation. These numbers are apportioned between age groups 0 to 19 and 20 to 59 in proportion to the population numbers in these groups. As in all these calculations, exposure at ages 60+ are ignored. This results in around 250,000 exposures at around 0.001 and a further 80,000 at higher levels (see Table 3 below).

A54 Together, this suggests around 1.5 million people with non-occupational exposures centering on 0.001 (we impute some of these into the under 20's category at present, although this has no effect on the estimates for commercial propoerty). Altogether we therefore estimate that around 2.7 million individuals are exposed at this level, most (just over 2 million) coming from the general working population, and representing 8% of this group.

A55 We have already detailed our base exposure assumptions for occasionally exposed maintenance workers. The half million in this group comprises some one-third of the total, typically exposed at 0.04 f/ml for 2.5% of their working time.

A56 The size of the rest of the working population exposed at this level can be obtained from our assumptions used to derive costs (described at Annex C). We have been advised that some 40% of all commercial building space will be in asbestos containing buildings, of which some 20% will be in poor condition (floorspace is a better measure than gross numbers of buildings, since ACM containing buildings tend to be slightly larger than average). This indicates some 8% of workers will work in the proximity of asbestos that is in poor condition. We should also include those directly disturbing asbestos on a very occasional basis. As already noted, this could be a very large group in itself. However, given the uncertainty in estimating low levels of exposure, we make no further upward adjustment to the estimate. We do, however, believe that we have made a *conservative* estimate of occupational exposure at these levels.

A57 Apart from occupational exposure, the rest of the working population will have some opportunity for exposure, either as bystanders of the activities of the first three groups (especially the maintenance workers), or from sporadic and background exposure levels.

A58 Outside the workplace too, people will be exposed, though to generally lower levels, since a lower proportion of domestic than of commercial property contains asbestos in quantity. Although these levels are lower, individuals spend a greater proportion of their time outside the work environment than in it. Theoretically, it could be argued that non-occupational exposure time should be reckoned at 3.2 times occupational exposure time given the ratio between working and non-working time. But something approaching a third of non-work time is spent asleep, and opportunities for generating exposures will be greater during waking hours. In addition, a significant amount of non-work time could be spent out-doors. We will take non-work exposure time to be equivalent to work exposure time, whilst recognises that this gives a conservative estimate.

A59 The rest of the population is divided between the two lowest exposure levels - 0.0001 f/ml and 0.00001 f/ml, broadly speaking the first representing urban outdoor exposures, and the second rural outdoor exposures. These exposure levels produce predicted risks at the individual level which can reasonably be described as negligible. But aggregated over the whole population some contribution to total asbestos mortality can be expected. However, since the extrapolation of risk becomes increasingly questionable as levels fall, for our best estimate of mortality we exclude the effect of exposures at these two levels.

A60 As already stated, DIY activity in owner-occupied homes (and at least some DIY activity in rented accommodation) will lie outside the scope of government regulation. Much out-door exposure also cannot be regulated directly, although it may be reduced by controlling exposure from maintenance work at source.

A61 In our preferred best estimate, we simply exclude all exposures at 0.0001 f/ml and below. This has the effect of reducing overall preventable deaths by around 10%. In fact, we believe background exposure would eventually be lowered by the proposals, and to that extent we are under-estimating benefits.

Step 2: Summary of current exposure levels and modelling assumptions

A62 Table 3 (overleaf) shows the exposure distributions and numbers exposed in the broad occupational categories described above on a typical working day. (The exposure distributions are also shown in cumulative percentage terms in figure 4.) In order to calculate the level of risk this exposure pattern presents in relation to historic exposures, we estimate the annual level of deaths that would eventually be generated by the long term continuation of this exposure pattern. Over an extended period of time the same individuals would not experience the same exposure level from day to day. Furthermore, a given individual would not be expected to spend their entire working lifetime within the same job category.

A63 In order to model the sharing of exposure over time, and the flow of individuals through these job categories over a working lifetime, we assume a turnover factor for each of the three highest exposure job categories. For example, we assume that over a working lifetime (40 years) 10 times as many people will at some time work in a demolition or asbestos removal job than are involved in these jobs on a given current day. (This is consistent with data on individuals having statutory asbestos medicals as asbestos removal workers over the past 14 years.) Smaller (5-fold and 2.5-fold) working lifetime turnover factors are assumed for the larger, less specialised categories of maintenance worker and other building work respectively. These estimates are based on the Labour Force Survey, which provides estimates of time with current employer, and also on whether the respondents occupation has changed over the last year. However, for our purposes, this is complicated by the fact that individuals may move between both employers, and also detailed occupation, but still be exposed to asbestos.

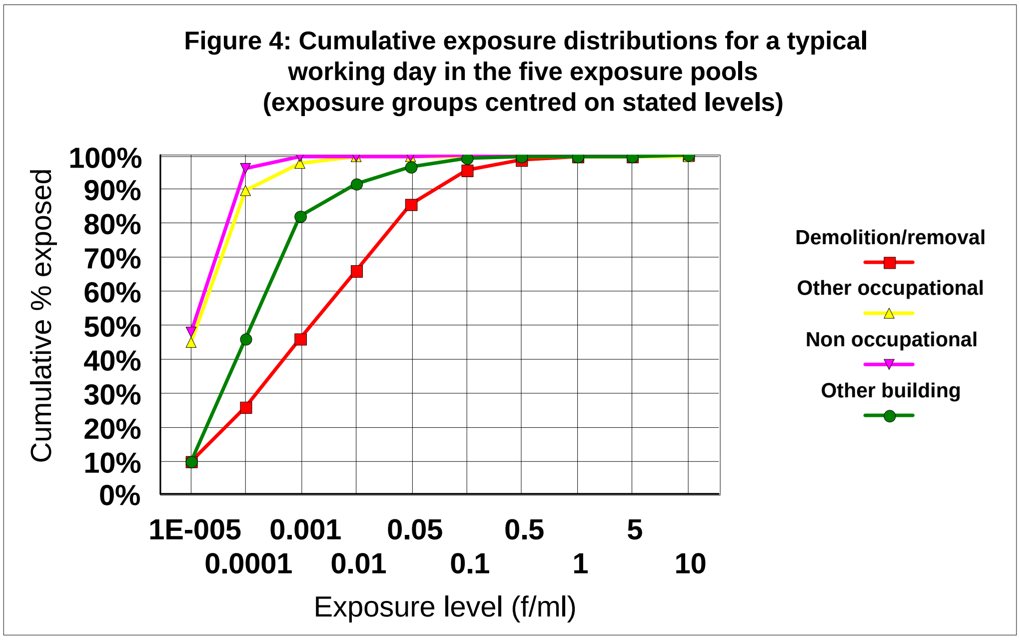
A64 The working lifetime exposure distribution for the group of individuals who have *ever* worked as a demolition or asbestos removal worker will not be the same as that for this group of workers on a given day, but will depend on what other job categories these individuals have occupied over their working life. For these calculations we have assumed that workers in demolition and asbestos removal at some time in their working life are drawn from the "other building work" distribution. In other words this group is formed by adding to the numbers for demolition/removal on a given day a proportion of the "other building work" drawn pro-rata from the exposure distribution of that group. The average exposure in the resulting group is consequently a weighted average of the demolition/removal and other building groups for a given day.

Table 3: Occupational exposure distributions assumed

	Exposure distributions on a given current day					Average daily exposure distribution in working lifetime pools (taking account of turnover)				
Exposure level (f/ml)	Asbestos removal/ demolition	Regularly exposured maintenance	Other building jobs	Other occupations	Total	Asbestos removal/ demolition	Regularly exposured maintenance	Other building jobs	Other occupations	Total
10	9	120	8	0	137	9	120	7	0	137
5	17	241	77	0	335	25	241	70	0	335
1	170	2,406	774	13	3,363	247	2,406	699	11	3,363
0.5	510	7,217	7,742	131	15,599	1,275	7,221	6,989	114	15,599
0.1	1,700	24,055	38,708	1,310	65,772	5,525	24,103	35,006	1,138	65,772
0.05	3,400	48,110	77,415	13,097	142,023	11,050	48,591	71,003	11,378	142,023
0.01	3,390	48,110	154,831	523,883	730,214	18,690	67,354	189,040	455,130	730,214
0.001	3,400	48,110	557,390	2,095,531	2,704,432	58,480	125,087	700,347	1,820,518	2,704,432
0.0001	2,705	38,127	556,531	11,772,814	12,370,176	57,700	470,585	1,614,117	10,227,775	12,370,176
0.00001	1,700	24,055	154,831	11,787,364	11,967,950	17,000	457,047	1,253,487	10,240,416	11,967,950
total	17,000	240,551	1,548,306	26,194,143	28,000,000	170,000	1,202,755	3,870,765	22,756,480	28,000,000
mean level	0.057	0.057	0.010	0.00036	0.0014	0.014	0.012	0.0037	0.00036	0.0014
..with lowest two levels set to zero	0.057	0.057	0.010	0.00031	0.0014	0.014	0.012	0.0037	0.00031	0.0014
turnover	10	5	2.5							

Table 4: Domestic exposure distributions assumed

Exposure level (f/ml)	Exposure distributions on a given current day Ages 0-19	Ages 20-59	Total
10	0	0	0
5	0	0	0
1	0	0	0
0.5	0	0	0
0.1	666	1,454	2,120
0.05	3,132	6,840	9,972
0.01	21,905	47,831	69,736
0.001	494,932	1,080,711	1,575,643
0.0001	6,988,182	15,259,082	22,247,264
0.00001	6,988,182	15,259,082	22,247,264
			0
total	14,497,000	31,655,000	46,152,000
mean level	0.00012	0.00012	0.00012
..with lowest two levels set to zero	0.00006	0.00006	0.00006



A65 In a similar way, the extra individuals in the "ever maintenance" and "ever other building" groups are drawn from the "other occupations" group. The resulting numbers and exposure distributions are shown in the last four columns of table 3.

A66 Within each group it is assumed that all individuals have an equivalent probability of days at each exposure level. The predicted asbestos related mortality is accordingly calculated assuming a working lifetime (age 20 to age 60) exposure at the group average using the risk factors suggested by Hodgson and Darnton (2000).

A67 A further set of assumptions has to be made about the proportions of the different fibre types in the assumed exposure. Most of the fibre in asbestos products was chrysotile, but the kinds of product into which chrysotile was incorporated, and the location of these products in buildings implies that the proportion of fibres in exposures that are likely to be generated is much more heavily weighted towards the amphibole fibres than would at first seem likely. One basis for assessing the likely proportions is to assume a "release factor" to reflect the different probability that fibres of a particular type will be released. We believe that the release factor for the amphibole fibres is at least ten times that of chrysotile. Applying these factors to the amounts of the three fibre types which were imported in the 1960s (the peak period for imports) implies exposure proportions of around 10:60:30 for blue, and brown and white asbestos respectively. This is broadly in line with the limited air monitoring evidence available. The difficulty of using direct evidence of air monitoring is that this is only done in situations where exposure to asbestos is known to be taking place, or to be likely to take place. It cannot be taken to be representative of the exposures that will occur in situations where this is not known.

A68 Our best model assumes the above proportions for the proportions of the three fibre types in airborne exposure, with variants 15:50:35 and 5:50:45. The central pattern of fibre mix together with the exposure distributions shown in figure 3 imply a long term annual total of 93 mesothelioma deaths (based on overall death rates of the 1970s), of which 71 will be men. This is assuming that all the highest exposure individuals are male and the rest of the exposed population is divided in equal proportions of male and female.

FURTHER STEPS IN THE MODELLING PROCEDURE

Step 3: Calibration of risk generated by estimated current levels to exposure index in population model

A69 The next stage in the procedure (step 3) is to calibrate the risk generated by the exposure outline above by estimated current levels to exposure index in the population model. The predictions of annual mortality levels generated by applying the risk factors from Hodgson and Darnton relate to deaths before age 80, and to a population subject to the overall death rates of the 1970s.

A70 To determine what constant level of the exposure index in the projection models corresponds to this predicted annual death rate from mesothelioma, we have to find the constant exposure level within the model which predicts the appropriate number of male mesothelioma deaths at ages up to 80 in the 1970s. The improvements in survival to the ages where mesothelioma death rates are highest between the 1970s and now (and the further improvements which are expected in the future) mean that the predicted annual total generated by a constant exposure rises over time. To generate 71 annual male deaths from mesothelioma in the 1970s from a constant exposure level in the projection model, the exposure index needs to be set at 4.2% of the peak.

Step 4: Estimating how this current level of population exposure would change over the next 50 years if no additional control action was taken.

A71 Taking exposure at 4.2% of the peak value as our assumed present level, we next estimate its future path to fall in proportion to the predicted demolition rate of the generation of buildings with high probability of containing asbestos materials (step 4). Existing regulations will apply on demolition, but the benefits of any asbestos management programme ceases at this point. Data from the valuation office suggested an average building life of fifty years. We had therefore previously reduced both the costs and benefits attributable to the proposals by 2% each year.

A72 This figure is based on the median age of commercial buildings (around fifty years), which is discussed in more detail at the front of Annex C, (including table C1). We have since pursued data on demolition in the commercial sector from a number of governmental and industry sources. We have not been able to estimate a global figure for demolition. However, we know from our work on housing that the demolition rate for the cohort of older buildings containing asbestos will rise on a yearly basis, as these buildings reach the end of their lives. We therefore apply a demolition rate of 1% of current stock a year currently, rising to 4% by the end of the period, and giving an average of around 2%. The effect of this change is to slightly increase benefits, since commercial buildings (and therefore the on-going benefits from establishing a management system) last longer from the present. The effect is through discounting, rather than any change in the average demolition rate.

A73 We are now in a position to estimate future mortality from asbestos, in the absence of any further action (or increased compliance with existing regulation) other than routine demolition. This is described in **Annex B** below.

ANNEX B : BENEFITS

Total current mortality given current exposure

B1 The previous section detailed our modelling procedure and set out our assumptions about the distribution of exposure levels amonst the current working and non-working population. Weighted by the numbers in these occupations categories according to the Labour Force Survey, these assumed levels imply an overall average occupational exposure of 0.00014 f/ml, and a non-occupational exposure of 0.00006 excluding the lowest background exposures.

B2 We now apply the risk coefficents as published in Hodsgson and Darnton, use this to benchmark the modelled exposure index, and then project this into the future. We lower this future risk to the extent that we expect asbestos to be removed on demolition, and we exclude the lowest two levels of exposure, which we can term `background' exposure.

B3 The uncertainties underlying this calculation are also considerable, particularly those associated with the risk factors at these - generally - low levels of exposure. Table B1 (overleaf) shows our best estimates and also the effect of varying the key input assumptions: the risk factors taken from Hodgson and Darnton (2000), the fibre mix assumption, the size of the regularly exposed maintenance group and the turnover of individuals through exposure groups.

B4 It can be seen that the possible range in risk factors has a five-fold upward and eightfold downward impact on the estimated mortality levels, while the other assumptions introduce less than a twofold in total uncertainty. However the highest two risk factor (which are shaded in the table) variants correspond to annual deaths in the 1970s well above the level predicted by a constant exposure index at 14% of the peak level (which is around 250). Given the statisitcal evidence we have already presented in table A2 - that the exposure is highly likely to have fallen to less than 14% of the peak - we exclude these estimates as not credible.

Principal uncertainties in the estimates

B5 In assessing the risk generated by low levels of asbestos exposure (below the levels at which risk can be established by empirical observation), the form of the relationship between exposure and risk must be assumed. The usual assumption is that exposure and risk are proportional (a linear relationship). However, the risk model proposed in the most recent published quantitative risk assessment for asbestos (and the only one that has assessed all three main fibre types quantitatively) presents evidence that the risk for lung cancer and peritoneal mesothelioma vary more than proportionately with exposure, while the risk for pleural mesothelioma varies less than proportionately. That is to say that if exposure halves, the risk of lung cancer and of peritoneal mesothelioma will more than halve, and that for pleural mesothelioma will reduce by less than half. Our best estimate uses this non-linear extrapolation.

B6 A linear extrapolation of risk would give predictions at the lower end of the scale shown in Table B1. Assuming a linear relation, and setting all other risk factors to their minimum credible level for all fibre types generates the very lowest figure in Table B1. In fact, we believe a central estimate given a linear model would be around double these minimum estimates, in other words around 25 deaths each year. In addition, we calculate that risk factors proposed in a Health Effects Institute report on asbestos (which are calculated on a linear basis) would predict annual deaths of about a third of our best estimate, giving a figure of around thirty, although the validity of reading across these risk factors would need to be confirmed.

B7 At low exposure levels, the possibility of a threshold for risk is also a subject of scientific debate. The more than proportional risks assumed for lung cancer and peritoneal mesothelioma have a similar effect to a threshold since the risks reduce more rapidly with falling exposure. HSE's review of fibre toxicology suggested that "a practical threshold was likely" for asbestos induced lung cancer. Some commentators have argued for a threshold for mesothelioma risk, but this has not been generally accepted.

Table B1: Central estimate of annual mortality that would be generated by constant exposure at assumed current levels, and impact of variant assumptions.

Risk factor for each fibre type			Percent of each fibre in exposure (blue:brown: white)	Turnover factors	Size of regularly exposed maintenance group	Predicted annual mesotheliomas	Predicted annual lung cancers	Total predicted annual deaths
Blue	Brown	White						
Impact of risk factor								
max	max	max	10:60:30	mid	mid	495	59	554
best	max	best	10:60:30	mid	mid	333	50	385
max	best	best	10:60:30	mid	mid	246	17	263
best	best	max	10:60:30	mid	mid	100	13	113
best	**best**	**best**	**10:60:30**	**mid**	**mid**	**93**	**11**	**104**
best	best	min	10:60:30	mid	mid	92	11	103
best	min	best	10:60:30	mid	mid	50	10	60
min	best	best	10:60:30	mid	mid	55	3	58
min	min	min	10:60:30	mid	mid	10	2	12
Impact of fibre mix:								
best	best	best	15:50:35	mid	mid	111	10	121
best	**best**	**best**	**10:60:30**	**mid**	**mid**	**93**	**11**	**104**
best	best	best	5:50:45	mid	mid	61	9	70
Impact of regularly exposed numbers:								
best	best	best	10:60:30	mid	max(360k)	100	13	113
best	**best**	**best**	**10:60:30**	**mid**	**mid(240k)**	**93**	**11**	**104**
best	best	best	10:60:30	mid	min(120k)	86	9	95
Impact of turnover:								
best	best	best	10:60:30	max (5,5)	mid	96	10	106
best	**best**	**best**	**10:60:30**	**mid (5,2.5)**	**mid**	**93**	**11**	**104**
best	best	best	10:60:30	min (2,2)	mid	88	13	101

Note: Turnover factors varied only for ‘regularly exposed’ and ‘other building’ groups: highest both 5-fold, lowest both 2-fold.

B8 The consequence of these models is that as exposure levels fall pleural mesothelioma represents an increasingly large proportion of the generated risk. Also, the divergence between a linear and non linear view of risk increases as exposure moves away from the region where empirical evidence is available (ie historic occupational levels giving cumulative exposures of 10 to 1000 f/ml.yrs). For present conditions (if these were continued indefinately) we are looking at cumulative exposures for the vast majority of the population below 2 f/ml.yrs, averaging (on the assumptions set out in this RIA) 0.06 f/ml.yrs for occupational exposures, 0.004 f/ml.yrs for domestic exposures. These are factors of 170 and 2500 lower than the bottom of the empirically observed range. A linear model applies these factors as they stand. The non linear model for pleural mesothelioma reduces these two factors to 45 and 350, around a quarter and a seventh of the linear factors respectively. For lung cancer the non linear model applies higher factors: 790 and 26000, and thus reduces predicted risk between 5 and 10 times as much as the linear model. The net result is a reduction in predicted risk by a factor of about 3 (as evident at paragraph B6 above).

B9 The estimation of risk under current circumstances therefore depends crucially on which model in fact applies. There is no direct evidence on this issue, and the indirect evidence is limited and inconclusive. Convention would favour the linear model; and it is easier to envisage mechanisms that have a linear than a less than linear effect. Previous estimation has adopted a linear model, but this can partly be put down to difficulties in estimating a non linear effect rather than the fact that this view has been explicitly identified and rejected.

B10 On the other hand the occupational cohort data analysed by Hodgson and Darnton, which we believe significantly enhanced the position, suggests a less than linear effect. Moreover, the very widespread distribution of mesothelioma across the male population does suggest that low exposures can be implicated in mesothelioma causation. Interpreting mortality data is complicated by many factors. For example, only occupation at time of death is known, and not previous occupations which could have resulted in high exposure. Also, deaths in occupations which we would normally associate with low exposures could predominantly be the result of exceptionally high exposures in usual cases. However, we believe that the wide distribution of mesothelioma across the male population - including the observation that mesothelioma mortality in industries outside the clearly high risk groups does not differ significantly between manual and non-manual occupations - is suggestive of a non linear effect.

B11 Given these observations, a precautionary approach would favour the non linear model. The evidence is not clear enough for HSE to take a satisfactory scientific view. However, we believe a non linear approach is justified on the basis of a cautious interpretation of the evidence - for the purposes of making our best estimate of the benefits of the proposals which are now being put forward.

B12 Uncertainty of this kind is difficult to deal with. Further scientific review of the existing evidence is likely to be inconclusive. Better understanding of the mechanism of asbestos carcinogenicity may in future add weight to one or other of the models, and might ultimately resolve the issue. It is unlikely that this key issue could be resolved even with some considerable work. On the basis of available evidence, we adopt the belief believe that the relationship is non-linear as our working hypothesis. However, scientific resolution of this issue is not an early prospect, and may indeed never be achieved. But for the present action must be taken on one view, in the knowledge that this may ultimately prove to be the wrong one.

Total number of future deaths in all sectors (step 5 in the modelling procedure)

B13 Taking the best estimate annual mortality into the future, and correcting for demolition, leads to a total of 7,800 deaths arising from exposure to asbestos over the next fifty years, if no futher action other than routine demolition is undertaken.

B14 Given the lag between exposure and death, these deaths continure to occur up to the end of this century. The average number of deaths is 78 in each future year, and the peak number is 158, which is predicted to occur in the year 2058. The profile of mortality is shown in graphical form at Appendix 2.

B15 These estimates include both deaths from lung cancer and also deaths to women. The numbers of lung cancer cases prevented in the future is more questionable than for the mesotheliomas. There are (at least) two additional sources of uncertainty. The typical levels of exposure we are now considering are at the low end of the intensity scale, and it is at least arguable (HSE's recent review of fibre toxicology has advanced this position) that there is a threshold for asbestos related lung cancers. In any case, the interaction between smoking levels and asbestos exposure, and the fact that the prevalence of smoking has fallen considerably over recent years, means that the number of lung cancers per mesothelioma is likely to be lower in the future than it has been in the past.

B16 The risk estimates for lung cancer in Hodgson and Darnton suggest that at the levels under consideration (and for our assumed mix of fibre types) the number of lung cancers caused will be about 11% of the mesothelioma numbers. This is a significant reduction from our previous assumption of 30%, and arises because we now assume that exposure is more widely shared across the population, giving lower average long term exposure levels, and decreasing the ratio of lung cancers to mesotheliomas.

B17 The projection modelling applies to males deaths only (due to the relative lack of data for female deaths), but the risk assessment from current exposures also generates predicted numbers of female deaths which can then be used to uprate the predicted male deaths from the production model pro rata. The uprating factor for the best model is 31%, which varies depending on whether `background exposure' is included.

Step 6: Apportioning total deaths between commercial and residential premises

B18 The final step in the modelling procedure is to apportion this future mortality between commercial and residential premises. In order to calculate this, we require our mortality estimates split between the different exposed groups. The number of deaths that would occur in the different exposed groups, given the exposures and other assumptions in our risk model is given in table B2.

Table B2: Predicted annual deaths by exposed groups (for constant exposure, and 1970s life table)

Exposed groups	Number of deaths		
	Mesothelioma	Lung cancer	Total
Removal/demolition	3	1	4
Regularly exposed building workers	27	4	31
Other building workers	20	5	25
Rest of working population	25	1	26
Domestic exposure (aged 20+)	5	0	5
Domestic exposure (aged <20)	13	0	13
Total	93	11	104

B19 The model used to provide our best estimate attributes 58% of total risk to be from occupational exposure to maintenance and building workers. The other 42% of the total risk is attributable to the background exposure of the people working/living in buildings containing asbestos. Of this 42%, the model attributes 17% of total risk to residents in all housing types, with the remaining 25% attributable mainly to background exposure in commercial buildings.

B20 The DTI construction statistics gives the total value of repair and maintenance activity, broken down by a broad building type. Around 48% of repair and maintenance is conducted on commercial buildings. Of the remaining amount, 32% is conducted in private housing and 20% on public housing.

B21 Private housing is known to contain far less asbestos than local authority provided housing. A generous assumption would be that private housing - on a unit by unit basis is four times less likely to contain asbestos than publicly provided housing (or equivalently a private house containing asbestos will contain one-quarter the amount of that found in local authority accommodation that contains asbestos). This together with the above figures indicates that around 7% of total risk will be in the owner occupied sector and around 29% in the local authority and rented sectors, giving a total of 35% after rounding. Some of this risk will relate to common areas of residential accommodation, which are included in these proposals. As noted below, we cannot separate these from the costs and benefits relating to rented accommodation as a whole, which are examined in a separate document.

B22 The remaining 65% of total risk is that attributable to workers conducting maintenance activity on commercial buildings and also the background exposure to the occupants of such buildings. Forty percentage points of this total risk in commercial buildings is risks to workers conducting maintenance on the building. This is consistent with the fact that a higher proportion of buildings in the commercial sector contain asbestos, and where it is found it would also be more extensive than in residential accommodation. Commercial buildings thus account for the majority of occupational risk to workers conducting maintenance work.

B23 Looking at background risk, the split between the commercial and residential sectors is more equal, despite the fact that asbestos is more prevalent in commercial buildings This is partly due to the longer time exposure of residents of housing compared to occupants of workplaces, and also to the higher population estimates.

B24 It should be noted that the above proportions relate to *current risk.* Since our model estimates a lower demolition rate amongst the residential sector, in the future the proportion of risk in the residential sector will increase. This can be demonstrated by the fact that although the residential sector accounts for 35% of current risk, 39% of preventable deaths are estimated to occur in this sector.

B25 The total number of deaths in the commercial sector is therefore estimated at 4,700.

<u>Valuation of health benefits</u>

Benchmark valuation of risk reduction

B26 To each of these future fatalities, we apply the Department for Transport (DfT) value of risk reduction, which is *equivalent to* a “value of preventing a fatality ” (VPF) of £1,060,000 (uprating the current figure to June 2000 values, which is the baseline for these estimates).

B27 This is not the value of compensating a named individual for the future certainty of a `premature’ death. It is an estimate of the average value that individuals would pay to gain a very small reduction in the chance of a premature death. For example, if this risk reduction was one chance per million (cpm), then we are saying that one million individuals would pay about £1 to avoid this risk. The statistical risk is equivalent to exactly one fatality in this example, and the VPF is equal to 1,000,000 * £1 = £1 million[4].

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4. For a fuller discussion of valuing safety benefit, see HSE Discussion Document DDE11 “Reducing Risks,

B28 It could be argued that this value is an overestimate with respect to asbestos. Typically people die from mesothelioma in, say, their 60s or 70s and so only a few life years are lost. The DfT benchmark figure assumes that the risk occurs evenly amongst all ages, so that the VPF figure would relate to those of average (ie prime) age. It is possible to convert the VPF figure into one which is dependent on life years remaining using a standard discounting technique[5].

B29 However, the DfT VPF would clearly be an appropriate baseline for prime age deaths due to asbestos. Furthermore, a crucial issue is one of contemporary risk. In many of the cases, we are reducing the contemporary risk to individuals already of relatively high risk and of prime age or younger. It is not clear, in this case, what the individuals value of risk reduction would be. For example, if it was the case that exposure would reduce the individual's remaining years by half (however many are left), then the individual's value of risk reduction may be similar to the DfT figure, at any age.

Adjustments to the DfT figure

B30 When considering any proposal involving carcinogens, HSE makes an additional adjustment to the DfT benchmark figure. Pyschometric evidence indicates that individuals have a particular dread of cancer, which suggests that individuals would place a higher value on avoiding the possibility of a cancer death.

B31 There is no allowance in the DfT VPF for the period of pain and suffering leading up to death. HSE has published[6] estimates of the cost to the economy of a range of injuries and ill health. Most of these estimates are calculated by using a "relative utility loss" index, where 0 equates to death and 1 to full health. A number of studies have ranked different states of ill-health on this scale. These range from a minor illness involving less than 7 days absence from work to a permanently incapacitating illness involving withdrawal from the labour force. The "relative utility loss" index would rank a permanently incapacitating illness at around 0.2 of the total `harm' of a fatality. Clearly, the loss attached to the period of incapacity alone leading up to a fatality by cancer would be at least as great as this. However, this amount would be highly unlikely to fully allow for the pain and suffering associated with the condition.

B32 We have not made any explicit allowance for individuals who have to give up work as a result of asbestos related disease. In societal terms, this represents a resource burden in that the individual is consuming whilst not contributing to national output (much of this loss is reflecting in actual payments by the state in pensions and benefits, but some loss will be born by the individual in lower income). Given the age at which asbestos related disease becomes manifest, and the fact that the time of incapacity preceding death is short (typically two years), lost output will be small compared to the subjective costs above.

B33 Finally, the DfT VPF includes a relatively small allowance for medical treatment. With respect to illnesses caused by cancer, we would expect medical treatment and associated costs (eg the value of time spent by carers, whether professional or family members) to be far

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Protecting People", HSE Books. For a detailed review of the research behind VPF, see "The Valuation of Health and Safety for Public Sector Decision Making" Michael Jones-Lee and Graham Loomes, CASPAR (Centre for the Analysis of Safety Policy and Attitudes to Risk), University of Newcastle upon Tyne.

5. "Valuing changes in life expectancy in England and Wales Caused by Ambient Concentrations of Particulate Matter" Maddison, D, Centre for Social and Economic Research on the Global Environment (CSERGE), Working paper GEC 98-06, 1998.

6. "The Costs to the British Economy of Work Accidents and Work-Related Ill Health in 1995/6", HSE Books.

higher than those associated with a road traffic fatality. However, medical treatment concerning a fatal condition (rather than treatment aimed at accident victims who can make a full recovery) would typically occur at some point in an individuals life, and be commonly associated with heart disease or cancer. In fact it can be argued that an early death by fatal disease is associated with an overall saving in medical cost terms, since the individual is less likely to consume healthcare associated with chronic but non-fatal conditions. Rather than attempt any adjustment, we simply note the marginal costs or cost-savings will be small compared to the subjective cost.

B34 Given all these factors, HSE has in the past used a reference VPF of double the DfT benchmark VPF when assessing the risks of carcinogens (for example when setting maximum exposure limits). We also double the DfT VPF for the purposes of this analysis.

Total value of health benefits

B35 Health benefits are discounted at 2% each year from 2000 onwards, as noted in the technical assumptions (this an additional 2% to the 2% which arises from building demolition). Applying the values of risk reduction we have already discussed, the total benefit of preventing all future fatalities from mesothelioma and lung cancer due to exposure from the year 2000 until the end of the appraisal period is estimated at £3.0 billion in present values, using the best model.

COST SAVINGS

<u>Reduced uplanned disturbance</u>

B36 A proportion of notifiable asbestos removal and encapsulation jobs derive from unplanned disturbance of asbestos by maintenance personnel. This normally occurs where personnel have not been informed about the location of ACMs or the presence of ACMs has not previously been identified. These unplanned works, in which additional disruption is often caused by contamination spreading beyond the immediate area, normally cost more than instances where ACMs have been identified in advance, notified, and dealt with accordingly.

B37 This cost saving was divided into two categories: the first category refers to notified asbestos removal jobs in larger buildings that would fall under the scope of Control of Asbestos at Work (CAW) regulations, the second category includes only non-notified removal jobs in smaller buildings which are not covered by CAW.

B38 The Asbestos Removal Contractors Association (ARCA) and Thermal Insulation Contractors Association (TICA) technical committee estimated that unplanned emergency work represents around 10% of the 30,000 notified asbestos removal jobs per year. The committee also estimated that in notified jobs falling under the scope of CAW unplanned work leads to additional costs of around 50% compared to pre-planned removal work. Assuming an average cost of £10,000 per removal job this would mean an extra £5,000 in costs per job. Thus, total cost saving per year, calculated as a product of unplanned emergency jobs and average additional cost of the unplanned work, was estimated as approximately £15 million for notified asbestos removal jobs.

B39 Cost savings for non-notified jobs were calculated in a slightly different way. We have already estimated the numbers of non-notified work likely to disturb asbestos in our calculations on the additional costs of CAD (see annex C). This number is then multiplied by proportion of emergency removal jobs (assumed same as for notified - 10%), number of buildings with asbestos (by building type). We then assume that, on average, an additional 2 hours are spent (by two personnel) in making the required arrangements to work safely. This is additional to the time that would have been taken if the ACM was known about. This calculation resulted in cost savings of £12 million for non-notified asbestos removal jobs.

B40 The new duties should significantly reduce the occurrences of unplanned disturbance of asbestos by maintenance or personnel. In common with the management duties, we assume these cost savings will steadily fall over the appraisal period as the amount of ACM in buildings falls. The total present value benefits are therefore estimated at approximately £400 million over fifty years. Of this, we estimate that around £200 million will occur in commercial and public buildings.

Reduced costs of building demolition

Reduced survey costs

B41 Action already taken as part of these proposals during a buildings lifetime should reduce to some extent the action that needs to be taken when that building is demolished. Before any building (unless it is known with certainty that the building does not contain asbestos) is demolished, an extensive survey for asbestos is required. Since the building is to be demolished, this will normally take the form of an intrusive survey. Since under these proposals, a sample survey will have already be conducted, we may expect some cost savings when this further work needs to be done.

B42 Though it is unlikely that the sample survey will in itself prove sufficient on demolition, this survey may have been able to positively rule out some areas of the building that do not need re-examination, and also indicate upfront some areas where the intrusive survey should be concentrated. In addition, according to our costings, a plan of the building and (possibly) a register of the asbestos positively identified will be available.

B43 In estimating these savings, we simply assume that all work done by the initial sample survey does not have to be repeated on demolition - but that all this work would have been required in the absence of the sample survey. This, of course, does not apply to call-out costs, which are fully re-incurred. This is an overestimate of cost-savings to the extent that there may be some repetition in the end survey, however we believe that this should be small, if the sample survey is of high quality (as we have allowed in the costings).

B44 The extent of these savings are very sensitive to discounting, since the building may come to be demolished a long time hence. Over the appraisal period, some 64% of buildings needing an initial survey will be demolished at some point. The undiscounted saving is roughly this proportion of the variable survey costs, or £137 million. However, this figure discounts to £39 million in present terms.

Reduced removal costs

B45 The same argument as immediately above applies to that ACM that is removed as part of a management process, and therefore does not have to be dealt with on demolition. In this case, the undiscounted costs are £182 million, relating to a proportion of all asbestos still present (some remains in place). It is possible that the management action will result in total removal of asbestos in a particular building, so that the fixed costs of removal (as opposed to surveying) will not be re-incurred. The discounted total cost of £51 million is therefore an underestimate of these cost savings. Taken together, the cost savings on demolition of £90 million in present values relating to early action is probably a fair estimate.

ANNEX C: COSTS

COMPLIANCE COSTS TO BUSINESS, CHARITIES AND VOLUNTARY ORGANISATIONS

Baseline of cost estimation and age of buildings

C1 We had previously adjusted our cost estimates for the fact that many buildings containing asbestos will be demolished over the fifty year appraisal period. We have further refined this change, and pursued data on demolition in the commercial sector from a number of governmental and industry sources.

C2 The valuation office provides data on the age of the building at the time of valuation. From this data, we can calculate the median age of commercial buildings, being the date at which half the buildings in a particular category were built before the date and half afterwards. The average age of buildings will be longer than the median age, since there will be a rump of buildings in each category that have particularly long lives. The median ages of the four types of building in the retail/industrial category are shown in the table below.

Table C1 : Median age of buildings in the retail/industrial category

Building Type	**Median year built**	**Median age**
Factories	1960	40
Offices	1964	36
Shops/resturants	1939	62
Warehouses/workshops	1967	34

C3 The median age of building may also be an underestimate of how long buildings will last from now on due to the large amount of construction activity in the late 1980's. Taking the above factors into account we estimate that the average age of buildings is in the region of fifty years. We note that shops/resturants have a median age of more than sixty years and therefore an average age of longer than this. However, as well as demolition some buildings may effectively be rebuilt (for example stripping down to the buildings shell and reconstruction). Whilst this is not always classed as demolition, all asbestos should be removed under controlled conditions in just the same way as if the building was demolished. We include these cases in our baseline of buildings demolished rather than attributing this action to ongoing management. Given an average building life of fifty years, we previously applied a constant demolition rate of 2% each year throughout the appraisal period.

C4 We have since pursued data on demolition in the commercial sector through various governmental sources and by consulting the National Federation of Demolition Contractors (NFDC). Several of the larger demolition firms were also contacted. We have established that there is no central source of statistics regarding the number of commercial buildings demolished each year. Some of the individual firms were able to provide us with estimates of the number of demolition contracts undertaken each year, but not the number or size of buildings that these related to. A further complication was that many demolition firms also undertook work on residential accommodation that they were unable to dis-aggregate from work on commercial buildings.

C5 We have not been able to estimate a global figure for demolition of commercial buildings. However, we know from our work on housing (where there are more reliable sources of data) that the demolition rate for the cohort of older buildings containing asbestos will rise on a yearly basis, as these buildings reach the end of their useful lives. We therefore apply a demolition rate of 1% of current stock each year, rising gradually to reach 2% after twenty five years of the appraisal period, an then accelerating to reach 4% by the end of the fifty year appraisal period. These assumptions lead to an overall average demolition rate of just over 2% each year, which remains consistent with the known age of buildings.

C6 We can assess our assumption on the age of buildings against the number of asbestos removal jobs on demolition of buildings currently carried out each year. This will be a proportion of the 30,000 notifiable asbestos removal jobs each year. The total number of commercial and public premises currently containing asbestos is estimated to be in the region of 500,000. Given the rate of demolition we have assumed we would therefore predict around 5,000 jobs arising from demolition in current years (this number will increase in future years). Some asbestos removal jobs will occur as a result of management action. In addition a proportion are carried out in residential property. Our assumption therefore is internally consistent.

Familiarisation with the proposals

C7 All managers of buildings under scope of the regulations will have to familiarise themselves with the provisions of the regulations and the contents of the ACoP. With regard to the nature of the duties involved, we expect the information contained in the ACoP should be sufficient to guide building managers about the best way to comply in the vast majority of cases. Further advice may well be taken from outside sources, but we include this in the steps taken once familiarisation is complete. Initially, we allow a total of one hour of management time (at a marginal cost of £28 per hour) for each 1000 m^2 of each building under scope. Thus an estate manager of 3 buildings each of 5000 m^2 would require 15 hours (including the time of other colleagues who may become involved), and a shopkeeper of a shop of average size (220 m^2: see below) would require a nominal 20-30 mins.

C8 We apply these figures to all commercial and public buildings built before 1985. This may be an overestimate in cases where it is known there is no ACM present, or ones where asbestos management systems are in place, however every employer responsible for buildings were there may be any ACM will have to become familiar with the proposals, and those that already manage asbestos will have to ensure that this is sufficient to meet the standards outlined in the ACoP.

C9 The total one off cost of familiarisation, given the numbers of buildings described below, would therefore be £33 million, incurred in the first year of the appraisal period.

Documentary research and visual examination of the premises (presumptive survey)

C10 The proposed ACoP does not require a survey to identify ACM to be undertaken in all cases before the two year period specified. There is also the option of undertaking a "presumptive" survey, in which material could be treated as if it could possibly contain asbestos, and the risks assessed on this basis. If the building is in good condition, and (for example) it was apparent that any ACM is overlaid or over painted with what is clearly not ACM, then no further action need be taken until work commences which is likely to disturb any asbestos present.

C11 We believe many duty-holders, especially those managing small businesses with their own premises, may take advantage of this option. However, for commercial premises, it is likely that some significant maintenance or refurbishment work would be undertaken at some future point, and that this would require a survey to be undertaken sufficient to identify any ACM. It should be noted that minor work could proceed on the presumption that ACM *may* be present, but work likely to lead to a significant disturbance of the structure of the building - even if in good condition - would need to be preceded by a survey identifying whether ACM is in fact present.

C12 We therefore assume that a survey aimed at identifying ACM takes place before between five and ten years from the start of the appraisal period, ie a maximum of between three and eight years from when it is proposed the regulations come into force. The exact assumptions are given below. Before this time, duty holders would have to undertake a visual survey of the premises, and they may also wish to examine any existing plans of the building. They should also draw up a provisional management plan, which would outline the steps that have been taken so far, the type of work that could be undertaken at present, and the type of work which would first require a more thorough survey.

C13 We allow around one hour of time for each thousand m^2 of floor area for this process, which varies in line with the `complexity' of the building (so that, for example, a hospital building of 5,000 m^2 would need around 6 hours to complete the process, but a small retail premises only 30 minutes).

C14 We apply these numbers to all commercial and public buildings built pre 1985, again this may be an overestimate as there may be cases where it is known that no ACM is present or where an asbestos management system is already in place and it is felt that a further visual inspection is not warranted. Balanced against this is the fact that there may be some asbestos present in a small proportion of buildings built after 1985. Again, we assume this initial activity is undertaken by a building or accommodations manager at a marginal hourly rate of £28. These basic steps would have to be undertaken within approximately eighteen months of the proposals coming into force. Costs are as follows:

Table C2: Cost of initial research and visual examination (presumptive survey)

Type of building	**hrs per 000 sq/m**	**Total cost (£m)**
Retail/industrial	0.5	31
Agricultural	1.88	3.7
Education	0.75	2.0
Hospitals	1.18	0.8
Other health care	1.18	0.8
State	1.49	1.1
Public	1.51	5.8
Places of worship	1.51	1.1
Total (rounded), £m	46	

Surveying for the presence of ACM

Nature of surveys

C15 RPS Thomson was commissioned to research some 300 surveys carried out over a period of six years for owners of a variety of buildings including schools, hospitals, housing and commercial premises. Thomsons initially considered three types of survey:

a a visual only and relative quick and cheap obligation, often undertaken by employees of the company;

b a survey undertaken by professionals, involving a degree of material sampling but without removal of fittings (e.g. false ceilings etc.) . This type of survey represents a depth of survey commonly undertake for clients; and

c a very detailed survey involving considerable sampling and some disturbance of fittings. Experience suggests that some clients do request this level of assurance but also that the number of negative samples analyses is significantly high.

C16 Thomson examined the effectiveness of each of these surveys in locating asbestos. With respect to the costs of each type of survey, HSE has sought to validate Thompson's initial estimates with information from specialist survey contractors and employers who have already implemented systems to at least the standard that would be suggested by the ACoP. In general, it was found that Thompson's initial estimates of the *unit* costs of surveying were reasonable, but higher than typical estimates provided by other contractors. The reason for this appears to be in the intensity and nature of sampling (if required). The cost estimates varied by nature of building and type of survey as suggested in the tables below.

C17 One respondent to the consultation has noted that this broad classification of the surveying methods used in practice does not correspond to the way in which previous HSE publications have sought to provide guidance on the most appropriate levels of surveying to use in different circumstances. HSE guidance (MDHS:100) points to the limited effectiveness of walk-through surveys. Nevertheless, our preferred cost estimates are based on sample surveying, which the respondent recognises is close to that recommended by HSE guidance.

Proportion of buildings requiring an asbestos survey

C18 Significant numbers of buildings have already had a valid and competent asbestos survey. The proportions of different types of buildings that have had a suitable survey was estimated by Thomson. However, many building owners or managers may be adequately aware of where asbestos is on their premises without the need for a survey. HSE recently undertook some research looking at asbestos awareness in the manufacturing and retail trades.

C19 This research indicates that around 10% of employers who have not had a specialist survey are aware of the presence of ACM in their workplace, and we take this figure to be indicative of the proportion who would not require a survey (at any point) to identify where ACM is. Of course, some may still opt for a survey. However there may be just as many employers who are able to identify any ACM using their own resources (building firms are an obvious example).

C20 For other sectors, the 10% figure was varied up or down in line with the proportions who have already had a survey undertaken (this is the same as saying that we assume general awareness in the sector is proportional to action already taken). These additional proportions were then subtracted from Thompson's original estimates. For agricultural buildings we assume 50%, as although we think agricultural buildings are less likely to have been surveyed in the past it is likely to be the case that many individual buildings may be made of non-asbestos containing materials. We have increased the proportion of public buildings requiring a survey following advice from a major demolition company that routinely removes asbestos prior to demolition.

Table C3: Proportion of buildings requiring an asbestos survey

Type of building	**Percentage requiring survey**
Retail/industrial	60%
Agricultural	50%
Education	33%
Hospitals	73%
Other Health Care	73%
State	60%
Public	53%
Places of worship	60%

Number of buildings requiring a survey

C21 We have made a very significant change to our estimates of both the total number and size of commercial buildings in the UK since the second consultation. This followed the publication of new and much improved figures from the valuation office. The 'Commercial and Industrial Floorspace and Rateable Value Statistics 2000' were published in October 2001. These were calculated on a significantly different basis to the previous estimates from 1995, both in the type of buildings included in the four bulk classes (factories, offices, shops/restaurants, warehouses) and the amount of floorspace excluded from the statistics. We had previously combined the 1995 figures with information provided by consultants to estimate total UK floorspace.

C22 On reviewing the methodology in the light of the new and more complete floorspace statistics from 2000, we discovered that we had substantially over-estimated the total floor-space of UK factories/industrial buildings. Further investigation also uncovered a 1997 research report “Non-Domestic Building Stock Project - Activity and Classification Of the Non-domestic Building Stock” - Centre for Configurational Studies (Open University August 1997). This report, covered all non-domestic buildings and provided estimates of floorspace for the majority of those buildings not included in the valuation office figures. These more precise estimates have supplanted our previous estimates of absolute numbers and average floorspace for those premises outside the four bulk classes.

C23 Our current estimates combine these two data sources. Estimates of number of premises and average area in the four bulk classes (factories, offices, shops/restaurants, warehouses/workshops) are taken from the valuation office data. The OU report gives us estimates of numbers of premises and size of buildings for virtually all other types of non-domestic building. In a small number of cases there was no floorspace data in the OU report for certain kinds of premises, these have been assumed or calculated from other sources. We believe this combined approach gives us the best possible estimate for total floorspace of all non-domestic buildings excluding agriculture. For agricultural premises we continue to use estimates of the number of commercial farms from the DTI small business statistics.

C24 A further change to our estimates is that we now calculate costs on a ‘per premises’ basis. A premises (or heriditament) is defined as a continuos or adjacent space appropriate for a single occupant. Most are either groups of buildings, individual buildings or parts of buildings. A large office will, if shared between several tenants or owners, consist of several heriditaments. These may occupy some whole floors, part of a floor, or space in, adjacent to, or associated with the building. Conversely a single large heriditament may be comprised of many distinct buildings, for example a large factory on a single site. Previously we attempted to account for the fact that a premises may contain several buildings, however, using the new valuation office to it is more convenient to work on a premises basis.

C25 There have been minor changes to some of the building categories from previous drafts. For example, ‘education’ now includes all state and private schools and also nurseries, special schools, sixth form colleges and universities. The ‘Public’ category now contains a wide variety of buildings including museums, libraries, leisure centres and public houses. ‘Places of worship’ now also includes cemeteries and crematoria.

Table C4: Number of premises requiring a survey

Type of premises		**No. of premises requiring survey**
Retail/industrial	Factories/industrial	180,417
	Offices	151,591
	Shops/restaurants	391,604
	Warehouses/Workshops	126,994
	Total Retail/Industrial	850,606
Agricultural		72,428
Education		12,744
Hospitals		1,428
Other healthcare		29,984
State		12,912
Public		120,539
Places of worship		32,476
	Total	1,133,118

Average size of premises

C26 The average size of premises was taken from the valuation office data and the OU report on the non-domestic building stock. The average size of premises in the table below is given in Gross External Area (GEA). This is a measure of area including all internal area and external walls. In many cases, this has been derived from measures of Net internal Area (NIA) and Gross Internal Area (GIA) using the multipliers given in the OU report. NIA is defined as space useful to an occupant's business and excludes common areas, stairwells, foyers, lift shafts etc. GIA includes all internal area but excludes external walls. It was felt that GEA was the most appropriate measure to use in calculating the costs of the proposals, since amounts of asbestos could be present in common areas and external walls. The conversion rates between GEA and GIA/NIA used in the OU report, vary according to the type and size of building (e.g. the conversion rate for small betting shops is 1.3, where as the corresponding rate for superstores is 1.2).

C27 In the light of the new data from the valuation office, the average size of a factory premises has been reduced from 2604m^2 to 978 m^2. The average size of all other types of premises has changed in line with the more precise estimates from the OU report. These have replaced our previous figures which in some cases were based on substantially smaller samples or 'best guesses' and tended to be over-estimates.

Table C5: Average size of premises

Type of building	Average Gross External Area (metres squared)
Factories	978
Offices	319
Shops/restaurants	220
Warehouses/Workshops	777
Agricultural	2,000
Education	2,854
Hospitals	14,265
Other Healthcare	658
State	1,426
Public	710
Place of worship	549

Cost of different surveys

C28 Table C5 shows the cost of surveying an average building of each type. Using figures provided by three different asbestos consultancies and combining them with estimates in Thomson's original report, we calculated costs per metre squared for three different types of survey for each building category.

C29 The different approaches to surveying can be placed into three broad methods: visual walkthrough; sample survey; and intrusive survey. We use the term `walkthrough survey' to mean a visual survey conducted by a qualified surveyor (either specifically employed for the work, or deployed from existing specialist personnel), as opposed to any initial visual inspection of premises carried out in house by non-specialists. RPS Thomson examined the advantages and disadvantages of each survey mentioned at the front of this section. Their conclusions can be summarised as follows:

a Walkthrough Accuracy varies with the experience of the surveyor, and an accuracy can approach 80% to 90% providing specialist surveyors are employed. There is generally no disturbance of asbestos during the survey, and protective equipment is generally not required. However, there is the danger that such surveys can become to be relied upon as definitive over time.

b Sample surveying These can vary in intensity, but would generally aim to detect all the asbestos in buildings that is fairly accessible by effectively ruling out all non ACM material. However, it may not be possible to sample some areas without further disturbing asbestos.

c Intrusive survey This is effectively a detailed sample survey in which there is some disturbance of fixtures and fittings under controlled conditions. This type of survey would aim to identify all ACM in a given building.

C30 The costs for each type of survey reported by the different consultancies were very similar. Figures quoted by Thomson were generally higher than these, but this is due to the intensity sampling in the more detailed surveys. In general, a sample survey would leave the vast majority of ACM undisturbed.

Table C6: Cost of different surveys per m^2 (£)

Type of building	walkthrough	Sample	Intrusive / destructive
Factories	0.22	0.38	0.54
Offices	0.22	0.38	0.54
Shops/restaurants	0.22	0.38	0.54
Warehouses/Workshops	0.05	0.09	0.14
Agricultural	0.05	0.09	0.14
Education	0.22	0.38	0.54
Hospitals	0.22	0.38	0.54
Other Healthcare	0.22	0.38	0.54
State	0.22	0.38	0.54
Public	0.22	0.38	0.54
Places of worship	0.22	0.38	0.54

Cost per building for survey type chosen

C31 These survey cost rates were multiplied by the average size of a building of each type to give the survey cost per building, for each type of survey. Following comments made in the previous consultation, we added to this cost a further 50%, up to a maximum of £150 to cover the cost of the preparation of drawings and the marking up of plans. Now that we are estimating costs on a per premises basis we increase this maximum to £250 as some premises may be very large.

‘Call out’ charges

C32 Following comments made in the most recent consultation we have now increased the ‘call out’ charge to £250. This call out charge was previously divided by the number of buildings at each site to obtain an average ‘call out’ charge per building. We are now estimating costs on a per premises basis rather than for each individual building. This charge is therefore applied in full to each premises requiring a survey, although in cases where a number of premises are present in one site (for example, a large shared office block) the ‘call out’ charge for each premises may be less.

C33 The cost of a survey for the average size premises in each category are shown in the table below. It should be noted that in cases where the premises is much larger than average, the survey costs may be several times the figures given below.

Table C7: Cost per premises for different survey types

	Cost per premises (£) for each type of survey selected		
	Walkthrough	Sample	Intrusive
Factories	565	801	1,032
Offices	353	430	510
Shops/restaurants	321	374	430
Warehouses/Workshops	313	359	409
Agricultural	411	532	658
Education	1,114	1,572	2,053
Hospitals	3,567	5,856	8,260
Other Healthcare	462	621	787
State	710	1,035	1,276
Public	479	650	829
Places of worship	427	559	698

Period during which surveying takes place

C34 As noted at the front of this section, surveying by specialist surveyors in order to positively identify the presence of asbestos will not need to be undertaken within the time period allowed for compliance with the regulations, provided that buildings are treated as if they contain asbestos, and the condition of any material that may contain asbestos is good.

C35 For education and healthcare facilities, public buildings and places of worship, we assume a specialist survey takes place at some point over the next five years. For commercial premises, we estimate that the majority will have to undertake a specialist survey within five years of the proposals coming into force (for example retail premises), but that one-fifth would undertake a survey up to ten years from this date (for example small industrial units), giving an average of six years.

C36 These assumptions do not change total undiscounted costs - a survey will need to be undertaken at some point (where it is required). However, they do change the present value of costs due to discounting. This can be seen as a real benefit of the proposals, in allowing flexibility as to the initial approach taken to asbestos management.

Total cost of surveying all premises

C37 Total survey costs were calculated by multiplying the average cost of each different type of survey by the total number of premises requiring an asbestos survey.

C38 The total cost of surveying all premises is estimated to be between £470 million and £730 million depending on the level of detail of the survey. Of this cost, around £50 million to £90 million will be borne by the government (including local authority) sector.

Table C8: Total cost of surveying all buildings

	Total cost per building type (£m) for each

	survey type selected		
	Walkthrough	Sample	Intrusive
Factories	102	144	186
Offices	53	65	77
Shops/restaurants	126	146	168
Warehouses/Workshops	40	46	52
Agricultural	30	39	48
Education	14	20	26
Hospitals	5	8	12
Other Healthcare	14	19	24
State	9	13	16
Public	58	78	100
Places of worship	14	18	23
Total	465	596	732

Number of surveyors available

C39 We assume that a surveyor can conduct 125 surveys per year of non residential premises, and that the surveys are equally spread over the time periods in the paragraphs above. The total of 1.1 million premises would therefore require a total of approximately 1,700 surveyors.

C40 Thomson estimates that there are between 2000 and 5000 surveyors capable of carrying out asbestos surveys at present. This figure is likely to rise in response to market forces if a duty to manage asbestos is imposed although this may have cost implications if any training is required. The proposals would need an increase in the numbers of surveyors of approximately 50%. Another factor to be considered is the current workload of the existing competent surveyors. This is likely to continue and will reduce the availability of these people to carry out the works. Our research suggests that there is not a great deal of spare capacity in the industry.

Cost of remedial and follow-up work

Costs of different methods of remedial control or follow up work.

C41 We estimate the costs of two different types of remedial work; encapsulation/repair, and removal of all ACM. We also present estimates of the cost of labelling ACM that is in good condition. Labelling is not the only solution that may be adopted however, and does suffer drawbacks. An alternative approach, for example, is to establish a permit to work system together with a written register of the location of ACM. Follow-up work will consist of all these different methods of ACM management, which we denote as “Recording”, “Encapsulation”, and “Removal”.

C42 The base estimates of costs were obtained from Thomson, who did an extensive audit of work previously undertaken amongst various types of property. We made some further adjustments to these figures where the sample size was small in Thompson’s original report.

C43 We also believe that the costs of labelling would be lower in practice than Thomson assume, since this should be a relatively straightforward exercise once a survey has taken place. Also, keeping a register would typically cost less than this amount. This approach would suggest that encapsulation/repair would typically cost around 15% of total removal costs, and recording around 2%. It should also be noted that costs in any particular case would depend on the condition of the ACM. Encapsulation of extensive ACM in very poor condition (if this were attempted) may well cost almost as much as it would to remove the ACM. However, the figures below are out-turn figures, and give average costs *where the action has been attempted* in the past.

C44 Given this, the table displays some quite considerable variation amongst the different building types. This will be due to the amount of ACM present where it is found, the type of ACM, its condition, and its accessibility. For example, Thomson note that where ACM is found in factories, it tends to be fairly extensive.

C45 Due to downwards adjustments surrounding the average area of typical premises, the costs presented in the table below on a per metre squared basis are higher than those previously quoted. We sought to confirm the below estimates by sending details to the Association of Asbestos Removal Contractors (ARCA), and also a major demolition company that routinely removes asbestos before demolition. Both organisations broadly supported our average estimates as covering all resource costs, including both removal and reinstatement. We increased the costs of removal of asbestos from hospitals, following advice from the demolition company of the difficult conditions that are sometimes encountered during such jobs.

Table C9: Costs of different methods of control (£/square metre of premises area)

	Cost of remedial/follow-up work (£/square m)		
	Recording	Encapsulation	Removal
Factories	0.73	14.5	36
Offices	0.13	1	10
Shops/restaurants	0.13	1	10
Warehouses/Workshops	0.07	0.5	10
Agricultural	0.07	0.5	10
Education	0.1	0.75	7.7
Hospitals	0.16	1.18	13.3
Other Healthcare	0.16	1.18	10
State	0.2	1.49	5.64
Public	0.2	1.51	6.43
Places of worship	0.2	1.51	6.43

Action taken (% of total buildings)

C46 We first estimated the proportion of buildings who would be likely to find ACM present once a survey had taken place. These proportions were based on the various sources noted above, in other words the experience of contractors and local authorities on dealing with asbestos management. In response to comments from the demolition company, we have increased the proportion of factories and shops/resturants where asbestos is found to be present following the survey.

C47 We were also advised that, in general when asbestos is found, around four fifths of it will be in good condition, and one-fifth in poor condition. For agricultural buildings we assume that 50% of the asbestos will be in good condition and 50% in poor condition

C48 Where asbestos is found in good condition, we assume that recording is the most efficient management solution (also given the additional risks of disturbing ACM in this condition). For asbestos in poor condition, we generally assume that 35% of the time it is removed, and 65% of the time it is encapsulated and then labelled. For educational establishments with ACM in poor condition, we assume it is entirely removed.

Table C10: Action taken (% of total buildings)

	Action taken (% of total buildings)			No action necessary
	Recording	Encapsulation / Repair	Removal	
Factories	22%	3.1%	1.7%	76%
Offices	11%	1.6%	0.8%	88%
Shops/restaurants	11%	1.6%	0.8%	88%
Warehouses / Workshops	11%	1.6%	0.8%	88%
Agricultural	21%	8.1%	4.4%	75%
Education	13%	0%	3.3%	83%
Hospitals	34%	4.8%	2.6%	63%
Other Healthcare	34%	4.8%	2.6%	63%
State	28%	3.9%	2.1%	70%
Public	25%	3.5%	1.9%	73%
Places of worship	17%	2.3%	1.3%	82%

Note: Columns do not sum to 100%, as some action included both encapsulation and recording.

Total cost of remedial work (£m)

C49 We are now in a position to calculate the total costs of remedial work. The table below was calculated in the following way: Total number of premises requiring a survey (by building type) * Average size (in metres squared) by premises type * Cost of remedial work (per metre squared) * Proportion of premises surveyed which require remediation broken down into type of approach taken.

C50 The total cost of remedial work is therefore estimated at £642 million. Around £60 million of this cost will be borne by the public sector. These are the costs that we believe will occur given the most likely courses of action following on from the ACoP.

Table C11: Total cost of remedial work

	Total Cost of remedial work (£m)			**TOTAL** (£m)
	Recording	Encapsulation / repair	Removal	
Factories	48	133	178	359

Offices	1.2	1.3	6.8	9.2
Shops/restaurants	2.1	2.2	12.1	16.4
Warehouses/Workshops	1.2	1.3	13.8	16.3
Agricultural	4	11.8	126.7	142.5
Education	1.5	0	28	29.5
Hospitals	1.5	1.6	9.5	12.5
Other Healthcare	1.4	1.5	6.9	9.9
State	1.7	1.8	3.6	7
Public	8	8.4	19.2	36
Places of worship	1	1	2.4	4
TOTAL	72	164	407	642

Costs of safety management system

C51 Thomson supplied figures on the time taken to set up a management system for three example premises. These figures were then scaled according to the amount of asbestos present to derive the average management time requirement for the remaining building types. Total costs per premises were calculated by multiplying this average time commitment by a fixed hourly rate of £28 per hour to give the average initial cost per premises. Total initial costs were calculated by multiplying total number of premises requiring recording and encapsulation of asbestos by the average initial cost of setting up a management system per building.

C52 In addition to this fixed proportion we have been advised that there will be an additional cost for re-surveying areas where there may have been some disturbance of ACM following building work. This will take the form of regular `condition' checks of ACM that has already been identified as being in vulnerable locations. We have expressed this work in terms of proportions of the initial cost, varied by the extent that ACM is likely to be disturbed in particular buildings each year (eg higher than average for schools and hospitals). Thus the total recurring costs of the management system includes a fixed proportion of the initial set up cost as well as an additional cost for re-surveying each year.

C53 Once a management system is in place, we assume there is no further remedial work required *as a result of these proposals*. In practice ACM would be routinely removed during renovation and demolition work, but we assume that these costs would have been incurred in any case. The amount of ACM remaining in place would therefore fall over time at the demolition rate estimated at the beginning of this annex. For simplicity, we assume that the recurring management costs also fall at this rate over the appraisal period.

Table C12: Management system: initial and recurring costs

	hrs per ’000 m	**Total hrs**	**Initial cost (£)**	**Total Initial costs (£m)**	**Sampling (%)**	**Recurring costs (£m)**
Factories	27	27	751	50	10%	6
Offices	5	1.6	45	1.3	10%	0.3
Shops/ restaurants	5	1.1	31	2.2	10%	0.5
Warehouse/ Workshops	3	1.9	54	1.3	10%	0.2
Agricultural	3	5	140	4	10%	0.7

Education	4	11	300	2	20%	0.7
Hospitals	6	84	2,348	2	20%	0.5
Other healthcare	6	4	108	2	20%	0.5
State	7	11	298	2	10%	0.3
Public	8	5	150	8	20%	2.3
Places of worship	8	9	253	2	10%	0.4
TOTAL				**76**		**13**

Disposal

C54 We would expect a widespread duty to manage asbestos to result in increased levels of disposal, compared to current levels. Asbestos removal work is a licensed activity and is required to be notified to HSE. At present, there are just over seven hundred licensed contractors, and HSE receives some 30,000 notifications for removal work during a typical year. This number has increased from a previous figure of just below 10,000, after which work involving the removal of asbestos insulating board came under license.

C55 Licensed contractors vary greatly in size and activity, ranging from large specialist removal firms who would be responsible for up to a thousand jobs a year, to general building contractors who would undertake their own removal work connected to their general building work as and when the situation arises. We estimate that some 450 of the 722 licensed contractors are active at any one time, and significantly involved in removal work.

Increased number of notifications

C56 Table C10 provided our estimate of the extent that asbestos would be removed rather than managed in situ, expressed as a proportion of all buildings (whether or not they contain asbestos). An estimate of the increased number of notifications can be made from multiplying this proportion by the numbers of buildings on which these estimates are based.

C57 This would indicate a total of 30,000 cases where asbestos would be removed from workplace premises, following a widespread duty to manage. If this work was undertaken anytime up to six years after the proposals came into force, then this would indicate an additional 5,000-6,000 notifications each year, an increase of around 20%. The Asbestos Removal Contractors Association (ARCA) have advised that anything more than an increase of around one-third in the number of notified works could only be accommodated by the industry in it's present form with difficulty, which would indicate that the expected increase in work relating to workplace premises could be accommodated by the industry at present.

Costs of disposal and amount disposed

C58 These costs are already included in the costs of remediation above. However, some asbestos is classified as special waste, and has to be disposed at land fill sites authorised to take special waste. This section is concerned with the identification of potential factors that might impact on the costs (and feasibility of) disposal of ACM via landfill. Two particular issues are whether there will be sufficient landfill capacity under each of the proposed options and (relatedly) the extent to which disposal costs will change in the future due to the options regarding hazardous waste disposal under consideration (and other factors, for example increases in the landfill tax rate).

C59 The special waste regulations are currently under review by DfT. We cannot say at present how consignment costs will change as a result of the review, however the Environment Agency will need to recoup its costs through fees and the overall level of charges is expected to remain much as now. It is impossible, as yet, to say how charges for individual consignments will be affected, since more charges may be recouped as a periodic charge. The true costs of consignment go beyond the consignment note fee and other proposals will also affect the overall costs to special waste producers. In addition proposed changes to the waste list (in conjunction with the Landfill Directive) *may* mean that in future some ACM can be deposited in non-hazardous landfills as it demonstrates the same properties as non-hazardous waste.

C60 ARCA have advised on the costs of disposal at present. The total costs of disposing of one skip of asbestos material is around £350, including the requirement to notify the Environment Agency of the movement. At present, a typical (ie most common in size) notified disposal job will cost in the region of £5,000 to £10,000. Advice from ARCA is that the costs of disposal will typically be in the order of 10% of the total cost of the job, or around £500 to £1,000. This indicates that the average amount of ACM disposed of would occupy between one and three skips - although it should be emphasised that asbestos removal work can vary greatly around this average in amount of material dealt with.

C61 Special waste skips (which are enclosed) are usually around 35 cubic yards in volume ($25m^3$), of which the material will occupy around 25 cubic yards ($18m^3$). The weight of each skip would depend on the type of asbestos, and also the water content (following the removal process) but would usually be between 10 and 15 tons.

C62 This would indicate a total additional amount disposed for the 30,000 additional notified works at workplaces of around 700,000 tons, taking the mid-point of the ranges, at a cost of around £25 million. Spread over six years, this would represent an increase in the amount of asbestos disposed compared to current levels of 20%. As a consistency check, the total costs of removal (under the ACoP approach) for workplace premises as reported above (which included disposal costs) is £400 million, indicating disposal cost would be around £40 million.

C63 The reason for the discrepancy is due to the fact that predicted amount of asbestos removed from the additional notified works relates to many larger workplaces (particularly factories) than removal work for an average job at present. The average cost of removal of all asbestos from factories following Thompson's estimates is £35,000, rather than the £5-10,000 for all jobs advised by ARCA. Disposal costs of £40 million would relate to the disposal of around 1.1 million tons of material, an increase of 30% if spread over six years.

Costs of proposals in common areas of residential accommodation

C64 The common areas of residential premises will be under the scope of these proposals. These are not included in the above estimates of costs. Previously, the total cost and benefits of applying proposals to the rented residential sector were examined in a separate document. The document currently estimates that the cost of the proposals for rented residential accommodation were £1.6 billion including full compliance with existing regulation. This compared with benefits of £1.8 billion.

C65 Three types of residential accommodation are likely to contain common areas. These are purpose-built high-rise flats, purpose-built low-rise flats and converted flats. We take the numbers of these three types of accommodation from the English house conditions survey -

1996 (EHCS), grossing up to account for Scotland, Wales and Northern Ireland. The numbers of these three types of accommodation, along with an estimates of the proportion built pre-1985 are shown in the table below.

Table C13: Numbers of accommodation with common areas, proportion built pre-1985 (EHCS-1996)

Housing Type	Number	Proportion built pre-1985
Purpose-built high rise flats	406,000	98%
Purpose-built low rise flights	3,227,000	81%
Converted flats	1,038,000	99%

C66 Following further discussions with a demolition company that specialises in asbestos removal and demolition of high rise flats, we now attempt to broadly estimate the costs in common areas of residential accommodation. The company informed us that for a typical purpose-built high-rise block of flats, common areas would account for around 10% of the total floor area. However, due to the greater prevalence of asbestos, common areas would account for around 15%-20% of total costs of removing asbestos from the block.

C67 We use these figures as representative for high rise blocks, whilst assuming that common areas in purpose built low rise blocks and converted flats account for a lower proportion of total area. These inputs allow us to estimate the proportion of costs in these three types of residential accommodation relating to common areas. It should be noted that these three types are more likely than average to contain asbestos.

C68 Costs are then apportioned by the number of units of accommodation of the three types in the various tenures. This is equivalent to assuming, for example, that if seven out of the ten flats in a block are private rented, then 70% of the costs in common areas will fall on the private rented sector.

C69 The total cost of the proposals in common areas is estimated at £200 million over the appraisal period 2000-2050. This is equivalent to around £110 million in present value terms. This cost, approximately divided between the four tenures is shown in table below.

Table C14: Present value costs in common areas by tenure (£m)

Tenure	Housing Type			
	Purpose-built high-rise flats	Purpose-built low-rise flats	Converted flats	Total
Local authority	15	35	1	**51**
Registered social landlords	2	14	1	**17**
Private rented	1	10	6	**17**
Owner occupied	2	20	5	**27**
Total	20	79	13	**112**

The Chemical Agents Directive

Duties on employers or contractors involved in building maintenance

C70 The proposals contain a new requirement on those responsible for undertaking any work on buildings that might disturb asbestos. We expect this duty to affect almost all employers in the building and maintenance sectors. However, employers in a number of other industries may also be affected, since they may do on-site work that could disturb fixtures and fittings. Employers in this group could include, for example, firms employing heating engineers, electricians, or specialist firms that install equipment.

C71 We expect that many of these assessments will be generic in nature as they will tend to involve work which varies little from site to site. Once an assessment has been done it should be possible to reproduce this with alterations specific to the job in hand. We therefore anticipate that the main cost is in the time taken to determine whether or not an assessment is valid for the particular job, and make any amendments that may be required. We estimate that this work will take on average 15 minutes of time for a building job managers time at full economic cost of £13 per hour. Since the assessment will use information already to hand on the location of the ACM, we do not include any further costs.

C72 Estimating the number of written assessments has proved difficult. The Building Research Establishment does not collect this information, and many different types of activity may disturb ACM. For illustration, we assume that the number of activities on a *per premises basis* likely to disturb ACM are in the region of 5 per thousand m^2 of premises space each year. Thus a typical small office (250m^2) may expect one such activity each year, whereas a large office (5,000 m^2) may expect around 25.

C73 Applying these costs to the above numbers of buildings likely to contain ACM gives total recurring costs of £14 million each year. In common with the management duties, we assume these costs steadily fall over the appraisal period as the amount of ACM in buildings falls. The total present value costs of duties required under CAD are therefore estimated at £200 million over fifty years. Of this cost, we estimate that around £80 million will stem from activity in commercial and public buildings.

C74 Finally, it should be noted that we have excluded significant building or maintenance work on large buildings where there is ACM present, since employers of workers engaged in these activities are currently required to provide written notification of this work under the Control of Asbestos at Work regulations.

Costs of accreditation for bulk analysis

C75 These proposals include a provision that organisations carrying out the analysis of bulk matter to identify asbestos will need to be accredited by an appropriate body complying with international standards (ISO 17025). Presently, 122 laboratories are currently accredited by the United Kingdom Accreditation Service (UKAS). It is believed that this represents the vast majority of all UK laboratories carrying out analysis. It is likely that these proposals will increase the number of accredited laboratories in two respects. Firstly, laboratories not already accredited will need to become so within a lead in period (which we propose to be two years), at least for analysis of materials. In practice, we would also expect many of these laboratories to become accredited for on-site sampling. Secondly, the duty to manage in itself will increase the demand for analysis work throughout the UK, and this may also increase the number of laboratories that become involved in this work.

C76 With respect to the first impact, we still need to establish the number of non-accredited laboratories, but believe this figure to be no more than fifty sites, and probably much less than this. For a provisional estimate, we assume fifteen non-accredited laboratories. With respect to the second impact, we have already calculated that there will need to be an increase of around 50% in the number of surveyors qualified to carry out asbestos surveys, given that the surveys themselves would be spread over a period of up to ten years. Initially, much of the increase in sample analysis work will be absorbed by existing laboratories, who may expand their operations. However, it is reasonable to suppose that new laboratories will undertake some of this work, and an increasing amount as time goes on. It is impossible to forecast this accurately, but if half the expansion is eventually accounted for by new laboratories, then this would mean an increase in current numbers from between 132 and 142 to between 165 and 178. This expansion would probably take place over the first five years, when the requirement for the analysis of samples is reaching it’s peak.

C77 This indicates that around seven new laboratories would apply for accreditation each year, though it should be emphasised again that this is a very provisional estimate. The fixed fee charged for accreditation (which also covers sampling) is currently £650, and covers the administrative costs of assessment. In addition UKAS usually carry out both a pre-assessment and post-assessment initial visit to the site. These vary according to the size of the site, but typically take one or two person-days for the pre-assessment visit, and three to four person-days for the initial post-assessment visit. After this, we assume the laboratories are visited on a yearly basis, and these visits take two person-days.

C78 UKAS daily charges are currently £627, which we assume recovers the full-economic cost of the work. However, we should also allow costs on the same scale for the organisations applying, both for administration and during visits. This would indicate the initial cost to the laboratories applying for accreditation would be between £6,300 and £8,800 (we take a mid point of £7,500), with recurring costs of £2,500. This does not include and work undertaken to meet accreditation standards, which would normally be required in any case to satisfy existing regulations and standards.

C79 This suggests costs £100,000 per year initially, rising to a maximum of £160,000, and then falling to £125,000 after five years. After ten years, we assume the number of laboratories active in the analysis of materials to identify asbestos falls linearly over fifty years as the amount of “new” analysis work decreases. Total costs over fifty years would be £1.8 million, in present terms.

Appendix 1: Installers and maintenance worker exposures and risks from asbestos. A report by the Health and Safety Laboratory

Summary

Data for the exposure of maintenance workers is quite sparse and is mainly available from the 1980's onwards. There is even more limited data on the exposures that installers of asbestos containing materials into buildings would have received in the 1960's and 1970's. Many installers would be maintenance and construction workers and other maintenance workers would also be working directly alongside them during the installation**,** or would be disturbing the debris and the newly installed asbestos materials as other services were put into the building.

Maintenance work is characterised by *activity-related episodic exposures,* i.e there are specific tasks known to disturb ACMs which are carried out only occasionally and/or are of short duration. For example, a plumber or gas-fitter may have to remove insulation to get at a pipe or an electrician may disturb ceiling tiles or wall panels for access. An individual maintenance worker may also do different jobs on different materials which make it difficult to calculate their cumulative exposure.

The maintenance worker data from the early 1980's is expressed as geometric means at around 0.1 - 0.2 f/ml, HSL data from the later 1990's for maintenance workers gave a geometric means for similar trades in the range of 0.04 - 0.05 f/ml and average arithmetic mean concentrations of 0.12 f/ml (0.14 f/ml for personal samples only) but this is unduly influenced by a small number of high results. The average duration of sampling, 67 min, and the median, 45 min, reflect that maintenance work on many materials is subject to a 1 hour limit. In many ways these results reflect best practice. Exposures to maintenance workers from a well controlled US hospital site in the early 1990's gave an arithmetic mean of 0.11 f/ml. This suggests that if well controlled the exposures to maintenance workers have been relatively low and have fallen only by about half with improved controls.

Any estimates of maintenance worker exposures must take into account that the levels during installation were much higher due to the amounts of material being disturbed, the lower level of controls applied (if any), the higher regulatory control limits at that time and lower awareness of the disease potential. The database of maintenance worker exposures suggest some lowering in exposures since the 1980's but the most important factor is whether the workers are aware they are disturbing the asbestos and therefore taking appropriate controls.

If the asbestos is disturbed without knowledge by maintenance workers, the exposures for a short period would be the same as the installers or particularly with the much higher usage and availability of power tools**.** However, in most circumstances much less of the material is disturbed for a much shorter period of time. The lack of data suggests that estimates of differences between the installers and maintenance workers are largely guesswork but at least an order of magnitude could be justified by the data found to date. Specific jobs such as the spraying asbestos coatings would have be much higher.

For current day maintenance work the knowledge that you are working with asbestos is perhaps the most significant determinant of the exposure that maintenance workers will receive.

Introduction

Personal samples only are considered in this report except where there is little or no other data available, area samples being noted as such in the tables. Where they are given in the source, static/area/environmental measurements almost always corroborate personal samples when the distance of the sampler from, and its position relative to, the source of airborne fibres are taken into account.

The results tabulated in this report are measurements of peak concentration, i.e. they have not been recalculated to obtain a TWA, except where this is specifically noted in tables.

Phase contrast microscopy (PCM - an optical method, see HSE guidance MDHS 39/4) measurements only are considered except where the transmission electron microscopy (TEM) electron results are thought relevant. Exposure limits are set for PCM measurements since these are the basis of most of the epidemiological dose-response data used to set the exposure limits. Counts of "PCM-equivalent" fibres by TEM are usually significantly higher than those by PCM as the thinnest fibres are not seen in the optical microscope. But TEM can be used to determine the airborne concentration of fibres positively identified as asbestos, whereas all fibres are counted by PCM. TEM results therefore usually give a higher fibre concentration that PCM because the smallest fibres are detected but the TEM measurements will be lower if it turns out that a high proportion of the fibres present are not asbestos.

The main difficulty in interpreting exposure data is that the airborne fibre concentration depends on many factors, of which the most important are:

a the nature of the asbestos containing material (ACM) - whether it is loose or bonded in a matrix, hard or soft, damaged or not;

b how vigorously the ACM is disturbed by the activity;

c whether the activity is carried out wet, dry or after sealing or encapsulation;

d what other control measures are in operation (LEV) and how much care is taken tominimise disturbance of the ACM.

All these may vary markedly even between apparently similar jobs and it can be difficult to disentangle the part which each plays.

Exposure Data

Installers

At the present time the published data found relating to the levels of airborne asbestos the installers of asbestos containing materials would have been subjected to are for chrysotile containing products (e.g. asbestos cement (A/C) and felt roofing products and A/C water pipes) which have continued in widespread use (see table1). Some data from the use of chrysotile containing fillers and the installation of wallboards was also available.
Examination of an old HSE database (asbedust) based on data from the 1970's yield 21 sample points coded building and construction which involved cutting and installing asbestos boards which gave an average of 3.2 f/ml (range 0.02 - 7.16). However, these results were

coded as continuous work and related to fixed site secondary manufacture. Later HSE databases (NEDB) are dominated by removal and manufacture.

Table 1: Work on installing chrysotile containing products

Personal exposure to asbestos during installation of:

Corrugated roofing sheets	Mean 0.025 f/ml	Max. 0.040 /m	(Anon, undated)
Corrugated sheets (screw fixing)	0.033, 0.006 f/ml		(Baujon & Authier, 1993)
Corrugated sheets (fixed direct to steel frame)	0.015, 0.036 f/ml		(Baujon & Authier, 1993)
Corrugated sheets (drill and fix)	0.031, 0.023 f/ml		(Baujon & Authier, 1993)
Flat sheets (cutting tool)	0.013, 0.013 f/ml		(Baujon & Authier, 1993)
Flat sheets (scribe and break)	0.004, 0.026 f/ml		(Baujon & Authier, 1993)
Flat sheets (special cutting tool)	0.031 f/ml		(Baujon & Authier, 1993)
Flat sheets (fix and clip)	0.009 f/ml		(Baujon & Authier, 1993)
Flat sheets (cut near work site)	0.009, 0.028 f/ml		(Baujon & Authier, 1993)
Roofing slates	Mean 0.015 f/ml	Max 0.030f/ml	(Anon, undated)
"Representative" AC sheets	≤ 0.15 f/ml		(CONSAD, 1990)
"Representative" roofing felt	Not detected - 0.6 f/ml		(CONSAD, 1990)

Asbestos Cement Water Pipes

Cutting with high-speed disc cutter.

Dry	60 f/ml	(Kumagai et al., 1993)
Wetted prior to cutting	48 f/ml	(Kumagai et al., 1993)
Wetted prior to and during cutting	63 f/ml	(Kumagai et al., 1993)
"Representative" pipe installation	0.02 - 0.06 f/ml	(CONSAD, 1990)

Fillers containing chrysotile (Rohl et al., 1975)

Pole sanding	Mean 10.0 f/ml	Range 1.2 - 19.3 f/ml
Hand sanding	Mean 5.3 f/ml	Range 1.3 - 16.9 f/ml
Dry mixing	Mean 47.2 f/ml	Range 35.4 - 59.0 f/ml

Wallboard (Hanaoka & Ebihara, 1998)

Cutting and fixing - electric circular saw with LEV

0.94 - 1.13 f/ml	Long term (129-191 min)
2.3 - 6.7 f/ml	Short term (11-15 min)
11.2 - 18.5 f/ml	Short term (15 min for both) measured close to saw

Previous estimates of work with asbestos were also given in other HSE/HSE publications such as EH 35 and by the advisory committee on asbestos (ACA, 1979).

Interestingly as the cement in A/C roofing is less resistant to weathering than the asbestos, levels during installation are lower than during some maintenance work, where the loose layer of weathered asbestos fibres are more easily released. Asbestos fibres also accumulate in the laps between sheets. Manufacturers have also taken steps to reduce dust emissions from new sheets by using surface coatings.

High exposure levels have been reported for cutting AC water pipes and similar levels (~ 30 f/ml) have been found by HSE in tests using abrasive wheels to cut asbestos slates. High exposures also occurred in connection with the use of fillers called speckling and taping compounds in the US) to repair cracks in walls, both when the dry powder is mixed with water and when the filled areas are sanded level and the cutting of wallboards.

The data suggests that lack of dust suppression and routine breaking and sawing during the installation of other less rigidly bound and high asbestos content materials, such as pre-formed pipe insulation and asbestos insulating boards (AIB), must have produced peak exposures in the 10's of fibres per ml on a routine basis. Sprayed asbestos coatings were known to be much higher during installation (~100 f/ml). See ACA, 1979.

As a general rule the more effort and abrasion taking place, the higher the airborne concentration of asbestos. The use of power tools has long been identified as one of the most important determinants of the airborne concentration.

Maintenance workers exposure: US data

There is some US exposure data for maintenance workers from the early 1980's onwards, much of which was summarised by CONSAD and Health Effects Institutes (HEI) reports. Paik et al., 1983 found geometric mean PCM personal fibre concentrations of 0.13 f/ml for carpenters, 0.13 f/ml for electricians, 0.08 f/ml for painters and 0.19 f/ml for sheet metal workers involved in renovation activities. Studies by CONSAD (1984, 1985,1990) used the maintenance / renovation worker data collected previously to estimate exposure levels for US maintenance workers. It was estimated that some 740,000 US maintenance workers had exposures of between 0.11 f/ml for repairing plumbing to 0 .75 f/ml for repairing dry walling, assuming no respiratory protection was worn. The CONSAD estimates are presented in table 2 along with the estimated numbers of workers, duration of activity and the calculated TWA exposure levels for various maintenance activities (table 3).

A literature review by HEI (1991) updated the available data base (table 4) and provided some previously unpublished data provided by several US based consultancies. HEI also carried out a detailed analysis of a large unpublished database supplied to HEI by Hygenetics Ltd, HEI (1992) and Shaik et al (1994). This gave levels from an operations and maintenance programme at a U.S. hospital and gave a mean of 0.11 f/ml for the 107 tasks monitored by 203 personal samples. Most of the work involved the disturbance or work close to sprayed fireproofing on I beams or thermal pipe insulation. The work was closely supervised and carried out as part of an operations and maintenance programme after a thorough survey of the ACMs in the buildings. A range of control methods were used to reduce dust emissions as detailed in table 4 below.

One of the most interesting results was that the airborne concentrations were all below 1 f/ml and the mean personal sample concentrations decreased with the time of sampling. Also, most maintenance jobs generally take a short time to perform.

These results also reflect the different regulatory limits at the time of sampling (OSHA, 1995). The Occupational Health and Safety Administration (OSHA) permissible exposure limit (PEL) in the 1970's was 12 f/ml for a 8 hour time weighted average, which had been reduced to 2 f/ml by the 1980's when the early CONSAD data on maintenance workers exposures was gathered. The PEL was further reduced to 0.2 f/ml by the early 1990's when the well controlled hospital maintenance was reported. It has since the mid 1990's been set at 0.1 f/ml It is likely that current asbestos exposures will lead to much lower asbestos related mortality than the predicted rise based on the 1940 cohort, which may be based on historical high exposures, which are no longer prevalent.

It is however, too important an issue to be complacent about and further work to measure maintenance worker exposures has been funded by the UK Health and Safety Executive.

[continued]

Table 2: Effect of Peak Exposure Levels From Maintenance Activities in Buildings[a]

Type of Maintenance Activity	Maximum Number of Workers Exposed	Estimated Exposure with and (without) Respirators [b] (f/mL)	Maximum Exposure (person years)	Average Activity Time Per Building [c] (hours)	Ratio of Ambient Exposure with Respirators [d]	Ratio of Ambient Exposure w/out Respirators [d]
Repair/replace ceiling tiles	38,650	0.045 (0.45)	1,067	2.33	0.66	6.55
Repair adjust HVAC/lighting	60,793	0.006 (0.31)	3,285	7.17	0.27	13.9
Other work above drop ceilings	4,847	0.006 (0.31)	469	1.02	0.04	2.1
Repair boiler	180,984	0.018 (0.18)	1,720	3.75	0.42	4.2
Repair plumbing	180,984	0.011 (0.011)	1,720	3.75	-	0.26[e]
Repair drywall	80,231	0.075 (0.75)	5,662	12.36	5.79	57.9
Repair flooring	65,338	0.02 (0.02)	22,437	48.98	-	6.12[e]
Repair roofing	127,621	0.012 (0.12)	3,740	8.16	—	—
Total maintenance	739,448	—	40,100	87.6	—	—

[a] Source: CONSAD (1990); reprinted with permission. [b] Does not include estimates for minor repair but includes reduction due to respirator usage. [c] Average activity time calculated using maximum exposure in person years times 1600 hours and divided by the EPA (1988b) estimate of 733,000 pubic and commercial buildings with friable ACM [d]Calculated from estimated exposure with {and without) respirators times average activity time divided by ambient level (1600 hours x 0.0001 f/mL).

[e] CONSAD considered that respiratory protection would not be worn if below 0.1 f/ml.

Table 3: Representative Exposure Levels, Absent Respiratory Protection, by Construction Activity.

Construction Activity	***Representative TWA Exposure Levels, Absent Respiratory Protection (f/mL)***
New construction	
A/C pipe installation	0.02 to 0.06
A/C sheet installation	< 0.15
Rooting felt installation	ND to 0.6
Asbestos abatement and demolition	
Removal	< 0.01 to < 8 (pipe insulation) < 0.01 to < 25 (spray-applied)
Encapsulation	0.03 to 0.28
Demolition	< 0.01 to 11
Renovation/remodelling	
Drywall demolition	0.15 to 11
Remove built-up roofing	ND to 0.2
Remove flooring products	0.02 to 0.04
Routine maintenance: commercial / residential	
Remove/repair/replace ceiling tiles	0.02 to 1.4
Repair HVAC or lighting	0.01 to 2.8
Other work above drop ceiling	0.01 to 2.8
Repair boilers	0.04 to 0.53
Repair plumbing	0.04 to < 0.1
Repair roofing	ND to 0.3
Repair drywall	0.02 to 1.4
Repair flooring	0.02 to 0.04
Routine maintenance: general industry	
Gasket removal and installation	< 0.1
Removal/repair of boiler insulation	<0.01 to 8
Removal/repair of pipe insulation	< 0.01 to < 0.1
Miscellaneous maintenance activities	< 0.01 to 2.8

source. CONSAD 1990 NDR = not detected

Table 4: Summary of PCM Results for Maintenance work at a US Hospital							
		Static			Personal		
Variable	No. of permits to work	Number of samples	Mean	Range	Number of samples	Mean	Range
By Degree of Asbestos Control							
None	36	38	0.0126	0.0004-0.0481	88	0.0915	0.0049-0.4196
Minor	21	24	0.0097	0.0017-0.0274	31	0.0752	0.0104-0.6805
Glovebag	11	20	0.0217	0.0032-0.1003	27	0.1443	0.0039-0.4601
Mini containment	27	67	0.0324	0.0004-0.4222	48	0.153	0.0052-0.8395
Maximum	3	26	0.0101	0.0020-0.0312	0	0	
Unknown	8	16	0.01	0.0041-0.0306	9	0.1	***0.0467-0.1878***
By Type of Maintenance Work							
Air Handling Unit Preventive Maintenance	25	30	0.0181	0.0041-0.1003	87	0.09	0.0087-0.6805
Miscellaneous Repair	37	63	0.01	0.0020-0.0982	48	0.13	***0.0039-0.5496***
Miscellaneous Installation	18	68	0.03	0.0004-0.4222	20	0.17	***0.0049-0.8395***
Clean-up of ACM	4	5	0.01	0.0017-0.0274	8	0.2	0.0414-0.6246
Cable Pulling	9	20	0.011	0.0040-0.0393	9	0.05	0.0240-0.0985
Relamping	4	0			~9	0.0469	0.0205-0.0929
Generator Testing	7	3	0.0041	0.0004-0.0102	18	0.0843	0.0075-0.2261
Fire Alarm Testing	2	2	0.0129	0.0090-0.0168	4	0.1654	0.0836-0.2693
By Type of Room Area							
Mechanical Room	61	105	0.0142	0.0004-0.1003	141	0.11	***0.0039-0.8395***
Lobby	5	17	0.0140	0.0004-0.0444	6	0.06	***0.0133-0.1904***
Doctor's Office	19	37	0.0445	0.0032-0.4222	15	0.0341	0.0154-0.0549
Corridor	5	12	0.0165	0.0040-0.0393	13	0.107	0.0186-0.6805
Other Patient Area	4	6	0.0120	0.0073-0.0197	6	0.1046	0.0337-0.1939

Table 4 continued: Summary of PCM Results for Maintenance work at a US Hospital

		Static			Personal		
Variable	No. of permits to work	Number of samples	Mean	Range	Number of samples	Mean	Range
Administrative	9	10	0.0070	0.0031-0.0161	19	0.1726	0.0052-0.6246
More than one type	3	4	0.0073	0.0032-0.0104	3	0.0489	0.0205-0.0929
By Removal of Asbestos							
No	75	101	0.0116	0.0004-0.0481	138	0.08	***0.0049-0.6805***
Yes	31	90	0.0286	0.0017-0.4222	65	0.17	***0.0039-0.8395***
0-2 hours	NAC	30	0.0128	0.0032-0.1003	110	0.1174	0.0051-0.6246
2-4 hours	NA	85	0.0221	0.0004-0.4222	79	0.11	***0.0039-0.8395***
4-6 hours	NA	41	0.0212	0.0004-0.2347	8	0.05	0.0167-0.1308
> 6 hours	NA	35	0.0176	0.0005-0.1600	6	0.02	0.0052-0.0333
By Relation of Airborne Concentration to Limit of Detection							
Greater than or equal to LOD	NA	181	0.0206	0.0020-0.4222	193	0.116	0.0052-0.8395
Less than LOD	NA	10	0.0027	0.0004-0.0078	10	0.01	0.0039-0.0255

[Continued]

Maintenance worker exposures: - HSE Data

An HSE study of UK maintenance worker exposures was carried out in the mid 1990's (Burdett and Revell, 1998) and is summarised in table 5. The survey was intended to cover a range of maintenance worker activities.

The data is categorised by the description of the workers job title or trade and shows the average exposure values by worker category (trade). The largest grouping is those where the worker category is unspecified, all the data for this grouping being from non-HSL sources. Only one value of greater than 1 f/ml was recorded (1.44 f/ml) when over a 10 minutes period a "trained" inspector (not HSE) investigate the vandalised ceiling of a garage.

Table 5: Breakdown by trade type. (Personal samples ranked by mean)

	Number	Max	Mean	Std. Dev.	Geo. Mean	HSL only (No)
Joiner	2	0.03	0.03	0.01	0.02	2
Electricians	36	0.2	0.03	0.05	0.02	36
Plumber	2	0.06	0.05	0.01	0.05	2
Unspecified	40	0.72	0.07	0.13	0.03	0
Gas Fitter	31	0.72	0.13	0.2	0.04	3
Inspector	9	1.44	0.21	0.46	0.06	9
Engineer	13	0.77	0.26	0.29	0.07	0
Plumber/carpenter	8	0.65	0.39	0.21	0.32	8
Demonstrator	2	0.58	0.54	0.06	0.54	0
Total	143					60

The data can be divided into three main categories, hospitals, education (schools and colleges) and domestic (houses, flats and associated annexes such as garages). In table 6 the fibre concentration data is ordered by worker category and by job description. The largest grouping being where the worker category is unspecified. For this analysis a number of samples which initially fell into this unspecified category have been reassigned to other categories were the job description, source and location were very similar to other samples from known worker categories.

Table 6: Data by category (Trade) and by Job								
		All (No.)	Max	Mean	Std. Dev.	Geo.Mean	G. Std. Dev.	HSL only
Hospitals:	All	12	0.02	0.01		0.01	1.31	12
Electricians	Ducts	8	0.01	0.01		0.01	1	8
Electricians	Ceilings	4	0.02	0.02	0.01	0.01	1.49	4
Domestic	All	80	6.96	0.36	0.93	0.08	6.34	32
Demonstrator:	Thermal seal	2	0.58	0.54	0.06	0.54	1.11	0
Electrician	All	2	0.02	0.02	0.01	0.01	1.63	0
Engineer	All	13	0.77	0.24	0.29	0.07	7.73	0
	Ceiling panel	2	0.62	0.32	0.43	0.08	18.51	0
	Door panel	5	0.62	0.23	0.3	0.05	8.96	0
	Side/base panel	3	0.77	0.46	0.27	0.42	1.71	0
	Side/base/door	8	0.77	0.31	0.29	0.11	7.46	0
	Flue	3	0.01	0.01	-	0.01	1	0
Gas Fitter:	All	30	0.72	0.14	0.2	0.05	5.08	3
	Servicing	16	0.47	0.1	0.14	0.04	4.31	10
	RACO	8	0.1	0.02	0.03	0.01	2.27	0
	Asbestos removal	2	0.68	0.34	-	0.68	-	0
	Simulation	4	0.72	0.4	0.25	0.33	2.07	0
Inspector:	All	9	1.44	0.21	0.46	0.06	4.63	9
	Boiler house	3	0.02	0.01	0.01	0.01	1.49	3
	Garage	1	1.44					1
Inspector	House ?	5	0.12	0.09	0.03	0.08	0.03	5
Joiner:	All	2	0.03	0.03	0.01	0.02	1.33	2
Plumber/	Central Heat	8	0.65	0.39	0.21	0.32	2.16	8
Plumber	Fitted cabinets	2	0.06	0.05	0.01	0.05	1.33	2
Unspecified	All	10	3.06	0.42	0.99	0.11	6.17	0
	remove AIB	1	0.01					0
	Spray absilock	1	overloaded					0
	heater/warm air	1	0.01					0
	Central H pipes	4	3.06	1.1	1.7	0.33	7.01	0
	Artex/drilling	3	0.16	0.16	0	0.16	1	0
Education	All	57	0.72	0.06	0.12	0.03	3.42	22
Electrician	Ceiling tile/lights	22	0.2	0.05	0.06	0.03	2.84	0
Unspecified	All	35	0.72	0.07	0.14	0.02	3.33	0
	Ceiling tiles	24	0.06	0.02	0.02	0.02	2.08	0
	duct/ valves	9	0.36	0.08	0.14	0.02	4.48	0
	removing AIB	2	0.72	0.49	0.33	0.43		0

The average duration of sampling, 67 min, and the median, 45 min, reflect the UK asbestos regulations that most maintenance activities are restricted to a maximum of 2 hours (or 1 hour per person). The results suggest a 4-hour TWA exposure of around 0.03 f/ml if only one job entailing exposure to asbestos is done in that time. In practice, it is probably more likely that several such jobs will be done close together over a few days and then perhaps no more for quite some time. The estimated 4-hour TWA may therefore not be very realistic. Making the further assumption that the job is done only 25 times per year gives approximately 0.002 f/ml as the equivalent of a TWA for work done continuously.

The above results are similar to those from the US data (415 measurements, 107 tasks) quoted in HEI (1991): the average fibre concentration was 0.11 f/ml with 95% of the results in the range 0.05 - 0.42 f/ml.

Maintenance worker exposures by material type

A number of other publications on maintenance worker exposures as well as the studies above have been reviewed in terms of material type. These materials considered were:

- Work on asbestos cement products;
- Work on asbestos insulating board;
- Removal and replacement of valve packing;
- Vinyl floor tile maintenance;
- Work on walls and asbestos insulating boards;
- Other types.

Work on asbestos cement products

Exposure data for this type of work, mostly on AC roofing, are summarised in Table 7. The removal and replacement of asbestos cement is also given, as this material does not require a licensed asbestos contractor to carry out the work.

The airborne fibre concentrations measured for work on AC sheeting, mainly roofing, cover a very wide range, from below the detection limit to 1.1 f/ml. The data compiled by CONSAD quoted in HEI (1991) give 0.12 f/ml as the estimated exposure for roofing repair and this is broadly in agreement with the detailed measurements from the literature. The range of fibre concentrations reflects the many factors which contribute to exposure, which are discussed most comprehensively by Brown (1987).

For removal of AC roofing and wall sheets whole (or in pieces if accidental breakage occurs), there is some evidence that wetting or sealing the sheets prior to removal does reduce exposure but the reduction is not as great as might have been expected. These types of AC sheet are dense and usually have a hard and smooth outer surface because they have to be reasonably weatherproof. Unfortunately this will make it difficult for water (or sealant) to penetrate into the body of the sheet and wetting or sealing may therefore not be very effective. As expected, cleaning with water jets gives lower exposures than by dry wire brushing.

There is also some evidence that AC sheets which are weather-damaged may give higher exposure levels on removal. Removal of the exterior walls gives lower exposures than removal of roofing which is more exposed to the weather. Exposures when installing new AC sheets or roofing are generally much lower than for removal, probably because the sheets are unweathered and have to be handled more carefully.

In contrast, exposures are higher when roof sheets are being removed as part of demolition than when they are being replaced or repaired; handling of the sheets was noted as being faster and much more vigorous during demolition with more visible dust being generated (Brown, 1987). Exposures when painting AC roofing seem to depend on whether the planks are moved by lifting or are dragged across the roof. According to Brown (1987), the key to reducing exposure during roof removal is a combination of careful handling and wetting before stacking to minimise abrasion of the AC sheets.

<u>Table 7: work on asbestos cement roofs personal exposure to asbestos:</u>

<u>All work on ac roofing and sheets</u>

Range	Not detected/<0.01 - 1.1 f/ml (from data below)	
<u>Roof Repair</u> "Representative"	Not detected - 0.3 f/ml	(CONSAD, 1990)
<u>Roof Removal</u> "Representative"	Not detected - 0.2 f/ml	(CONSAD, 1990)
Dry - replacing corrugated AC	0.01, <0.01 f/ml	(Roberts, 1985)
Collecting sheets and cleaning	0.24 f/ml	(Roberts, 1985)
Removal of corrugated sheets (detachment and sliding to gutter)	0.047 f/ml	(Preat, 1993)
Throwing sheets into lorry	0.161 f/ml	(Preat, 1993)
Removal of corrugated sheets (detachment, stacking on elevator, placing in pallets)	0.028, 0.038 f/ml	(Preat, 1993)
Removal of corrugated sheets (detachment)	0.018 f/ml	(Preat, 1993)
Stacking of sheets of pallets	0.032 f/ml	(Preat, 1993)
Removal of slates (detached with hammer)	0.064 f/ml	(Preat, 1993)
Sliding slates to gutter; throwing to ground	0.195 f/ml	(Preat, 1993)
Removal of slates (detachment and stacking)	0.037, 0.044 f/ml	(Preat, 1993)
Removal of slates (detachment and placing in container on roof)	0.050, 0.176 f/ml	(Preat, 1993)
Removal of slates (pulling off, stacking on elevator, broken slates thrown to ground)	0.100, 0.122 f/ml	(Preat, 1993)
Removal of slates (detachment with hammer, sliding to gutter)	0.068 f/ml	(Preat, 1993)
Bringing slates down and throwing into container	0.056 f/ml	(Preat, 1993)

Wet (but not effective)	Mean 0.020 f/ml	(Lange & Thomulka, 2000)

Roof Replacement

Dry replacement (severely weathered) - unfastening, removal, stacking, disposal, installation of new roofing	0.03 - 0.24 f/ml	(Brown, 1987)
Dry unfastening, removal, disposal, installation of new roofing (no stacking)	0.03, 0.03 f/ml	(Brown, 1987)
Dry replacement (severely weathered)	0.04 - 0.27 f/ml	(Brown, 1987)
Dry removal (painted)	0.07 - 0.32 f/ml	(Brown, 1987)
Wet removal (painted) and replacement (careful handling and wetting as stacked)	Not detected - 0.07 f/ml	(Brown, 1987)
Replacement (severely weathered) after lignin sulphonate treatment	0.23 f/ml	(Brown, 1987)
Replacement (severely weathered) after sealing with acrylic resin	0.03 - 0.08 f/ml	(Brown, 1987)
Replacement (severely weathered) after sealing with acrylic resin	0.04 - 0.26 f/ml	(Brown, 1987)

Roof Removal - Demolition

Dry (building collapsed)	0.10 - 0.47 f/ml	(Brown, 1987)
Dry (from scissors lift)	0.04 - 0.12 f/ml	(Brown, 1987)
Sheets stacked in confined space	0.30 - 0.53 f/ml	(Brown, 1987)
Sheets stacked in confined space (accumulated dust under laps and ridges)	0.34 - 1.1 f/ml	(Brown, 1987)
Wet	0.05 - 0.06 f/ml	(Brown, 1987)
Wet (sheets staked in confined space)	0.10 - 0.13 f/ml	(Brown, 1987)
Wet (sheets staked in confined space; accumulated dust under laps and ridges)	0.29 - 0.68 f/ml	(Brown, 1987)
Sealed with acrylic resin	0.11 - 0.32 f/ml	(Brown, 1987)
Sealed with acrylic resin (sheets stacked in confined space; accumulated dust under laps and ridges)	0.41 - 0.76 f/ml	(Brown, 1987)

Personal Exposure to Asbestos: Wall removal - Demolition

Dry	0.04 - 0.12 f/ml	(Brown, 1987)
Sealed with acrylic resin	Not detected - 0.05 f/ml	(Brown, 1987)
Painting (Brown, 1987)		
By roller (planks slid across roof)	0.22 f/ml	
By roller (planks slid across roof)	0.20, 0.12 f/ml	
By airless spray (planks slid across roof)	0.14 f/ml	
By airless spray (planks slid across roof)	0.11 f/ml	
By airless spray (planks lifted over roof)	0.01, 0.01 f/ml	
By airless spray (planks lifted over roof)	0.09, 0.12 f/ml	
Cleaning roof		
Dry wire brushing	0.36 f/ml	(Gillett, 1986)
Water jets	0.08 f/ml(Static “near workers”)	(Brown, 1987)
Water jets	0.10 f/ml(Static “near workers)	(Brown, 1987)
Removal of moss with pressurised water	0.173 f/ml	(Preat, 1993)
Removal of moss with pressurised water	0.003, 0.011 f/ml	(Preat, 1993)
Cleaning up roof debris after fire	< 0.01 f/ml	(Lewis & Curtis, 1990)

Work on Ceilings (AIB , plasters and sprays)

Exposure data for work on or near ceilings and ceiling tiles are summarised in Table 8. Significant exposures are reported for work on acoustical plaster ceilings and suspended ceilings and because of the widespread occurrence of suspended ceilings, it is not always possible to determine whether the exposure was due to the spray asbestos above the ceiling, asbestos debris on top of the tiles or the asbestos containing tiles themselves .

For electricians working on lighting, exposures vary from 0.01 f/ml to 0.31 f/ml with most airborne concentrations being at the lower end of the range. Fibre release probably occurs more easily from an acoustical plaster ceiling than from ceiling tiles and this may explain one of the higher results. Otherwise, it can only be noted that fibre concentration should depend on how vigorously the ceiling is disturbed during the work.

When ceiling tiles are removed whole by unfastening, exposures are relatively low and it appears that more significant fibre concentrations may arise during the subsequent cleaning. Very high exposures arise if the tiles are broken during removal and when the debris is cleaned up and bagged.

Table 8: work on ceilings/ceiling tiles: Personal Exposure to Asbestos

Lighting/Electrician

Re-lamping (hospital)

Mean 0.05 f/ml	Range 0.02 - 0.09 f/ml	(Hygienetics, 1990)

Inspect light fittings in acoustic plaster ceiling

Mean 0.09 ± 0.05 f/ml		(Keyes et al., 1994)

Clean light fittings recessed in acoustic plaster ceiling

Mean 0.25 ± 0.03 f/ml		(Keyes et al., 1994)

Dismantle and replace ceiling fans; inspect ceiling anchoring system

Mean 0.01 ± 0.01 f/ml		(Keyes et al., 1994)

Repair/adjust HVAC lighting

0.31 f/ml		(CONSAD, 1990)

Repair HVAC or lighting - “representative”

0.01 - 2.8 f/ml		(CONSAD, 1990)

Electrician (schools) - ceiling tiles/lights

Mean 0.05 f/ml	Max 0.2 f/ml	(Burdett & Revell, 1998)

Electrician (hospital) - ceilings

Mean 0.02 f/ml	Max 0.02 f/ml	(Burdett & Revell, 1998)

Ceiling Tiles:- maintenance type removal and replacement

Removing tiles by undoing fixing screws and placing tile in plastic bag; replacing with new tiles 0.038 f/ml (Gibson, 1989)

Removing and replacing tiles in suspended ceiling under fireproofing (some debris on ceiling disturbed)

0.12 ± 0.04 f/ml (Keyes et al., 1994)

Remove/repair/replace ceiling tiles - "representative"

0.02 - 1.4 f/ml (CONSAD, 1984)

Repair/replace ceiling tile

0.45 f/ml (CONSAD, 1990)

Unspecified (schools) - ceiling tiles

Mean 0.02 f/ml Max 0.06 f/ml (Burdett and Revell, 1998)

Engineer (domestic) - ceiling panels

Mean 0.32 f/ml Max 0.62 f/ml (Burdett and Revell, 1998)

Cleaning after removal of tiles - wait 2.5 hours then vacuum clean carpet, clean furniture with dry cloths

0.47 ± 0.09 f/ml (Keyes et al., 1994)

Cleaning after removal of tiles - Wait 3 hours then scaffolds and equipment cleaned with brushes and dry cloths, terazzo floor swept with broom

0.13 ± 0.02 f/ml (Keyes et al., 1994)

Ceiling Tiles: Large scale removal

Dry removal by breaking tiles (in enclosure with full RPE)

6.0 - 50 f/ml as 8-hour TWA (Stranks, 1997)

Wet removal by breaking tiles (in enclosure with full RPE)

2.7 - 7.8 f/ml as 8-hour TWA (Stranks, 1997)

Highest result attributed either to poor absorption of surfactant and water or build up of fibres as work progressed

Cleaning and bagging after dry removal (breaking tiles)

2.5 - 50 f/ml (Stranks, 1997)

Cleaning and bagging after wet removal (breaking tiles)

2.2 - 5.4 f/ml (Stranks, 1997)

Carpet removal after repairs to acoustical plaster ceiling

Mean 0.23 ± 0.04 f/ml

<u>Ceiling with debris or sprayed fireproofing</u>

Lifting out tiles (asbestos-containing debris on top)

Mean 5.45 f/ml (Hamilton, 1980)

Lifting out tiles (asbestos-containing debris on top); LVHV extraction with HEPA vacuum cleaner

Mean 0.0085 f/ml Range 0 - 0.01 f/ml (ENTEK, 1987)

Checking ventilation above ceiling with sprayed fireproofing

Mean 1.3 f/ml (Hamilton, 1980)

Inspection above ceiling with sprayed fireproofing; LVHV extraction with HEPA vacuum cleaner

Mean 0.02 f/ml Range 0 - 0.09 f/ml (ENTEK, 1987)

Cable-pulling above ceiling with sprayed fireproofing

Mean 0.93 f/ml (Hamilton, 1980)

Mean 1.1 f/ml Range 0.07-10.3 f/ml (Environmental Sciences, 1990)

Cable-pulling above ceiling with sprayed fireproofing; with “pacification” (various)

Mean 0.05 f/ml Range 0.02 - 0.10 f/ml (Hygienetics. 1990)

<u>Other</u>

Repair acoustic plaster ceiling (water-damaged); debris removed with dustpans, cleaning equipment and floor with dry clothes and broom

Mean 0.34 ± 0.11 f/ml (Keyes et al., 1994)

Work on suspended ceilings

0.31 f/ml (CONSAD, 1990)

Other work above suspended ceiling - “representative”

0.01 - 2.8 f/ml (CONSAD, 1990)

Work on Gaskets and Packings

Exposures (summarised in Table 9) appear to be lowest for work with spiral-wound gaskets, unless they happen to be damaged, and for wet removal of sheet gaskets. Low exposures are expected for spiral-wound gaskets in which the asbestos filler and binder is compressed between stainless steel spiral windings; they can usually be lifted out complete and there is less chance of asbestos being left on the seating surfaces.

The most serious exposures occur during dry work on sheet gaskets and on packing, the latter being more friable than gaskets. It is easy to see how high exposures may occur during fabrication and during removal and cleaning of the seating surfaces. It is not so easy to understand how high airborne concentrations arise during installation if a new gasket is simply put into place unless the process described as installation in some of the literature sources includes fabrication of the gasket and/or cleaning of the seating surfaces.

The highest airborne fibre concentrations occur when power tools are used, in particular for cutting with a band saw and cleaning with a power sander.

Table 9: work on gaskets and packings**:** Personal Exposure to Asbestos during:

Gasket removal and installation - "representative"	
<0.1 f/ml	(CONSAD, 1990)
Fabrication - cutting to size with various tools	0.001 - 0.017 f/ml **TWA** (CM)
Flattening rolled gasket material; cutting hand saw	<0.11 f/ml F
Cutting with hand saw	0.33 - 0.39 f/ml (CM)
Cutting with power shear and wheel cutter	0.34 - 0.49 f/ml (CM)
Cutting with band saw	2.2 - 4.9 f/ml (F)
Cutting with hand-held electric saw; power stamping	< 0.05 f/ml (Y)
NEDB average fibre concentration for	
"asbestos gasket production"	0.23 f/ml
Removal dry	0.05 - 0.44 f/ml (MM92)
Removal and cleaning of seating surfaces (scraping and brushing)	0.11 - 0.35 f/ml (CM)
Removal and cleaning of seating surfaces (power sander)	1.4 f/ml (CM)
Installation (may include cleaning of seating surfaces or fabrication)	0.13 - 0.29 f/ml (MM92)
Wet	
Removal and seating surface cleaning	<0.06 f/ml (CM)
Spiral-wound gaskets	
Removal dry	<0.06 f/ml (CM)
Removal wet	0.042 - 0.141 f/ml but mostly glass fibres from adjacent Insulation Exceptionally 0.242 f/ml for gaskets with damaged asbestos SR
Metal-jacketed gaskets	
No data - considered to be no potential for exposure as asbestos sheet encased in metal jacket	
Packings	
Removal dry	0.05 - 1.01 f/ml (MM92)

Removal dry	0.1 - 1.3 f/ml (MM93)
Installation	0.04 - 0.52 f/ml (MM92)
NEDB average fibre concentrations for	
“removal of asbestos packing”	0.21 f/ml
“packing”	0.21 f/ml
“re-packing”	0.24 f/ml

Literature abbreviations

F	Fowler (2000)
SR	Spence & Rocchi (1996)
MM92	McKinnery & Moore (1992)
CM	Cheng & McDermott (1991)
MM93	Millette & Mount (1993)

Work on Floor Tiles

Exposures are generally low for most types of work on floor tiles (Table 10) but significant fibre concentrations may arise when floor tiles are removed dry without prior wetting or with power tools. The asbestos fibres in floor tiles should be tightly held in the asphalt or PVC matrix.

The high fibre concentrations for ultra-high speed burnishing measured PCM are thought to be misleading as TEM measurements show very low concentrations of asbestos fibres and a high density of non-asbestos “fibres” as defined by the counting rules.

Table 10: work on floor tiles personal exposure to asbestos during:

Repair flooring

“Representative” 0.02 - 0.04 f/ml (CONSAD, 1990)

Spray-buffing - surface sprayed with polish and buffed to dryness

Range 0.024 - 0.295 f/ml (Edwards et al., 1994)

Mean 0.012 f/ml	Range 0.008 - 0.015 f/ml	Floor condition poor
Mean 0.006 f/ml	Range 0.003 - 0.008 f/ml	Floor condition medium
Mean 0.019 f/ml	Range 0.015 - 0.030 f/ml	Floor condition good

(Kominsky et al., 1998a)

Wet-stripping - removal of floor polish or finish with detergent and rotary disc machine

Mean 0.010 f/ml	Range 0.006 - 0.016 f/ml	Floor condition medium
Mean 0.006 f/ml	Range 0.004 - 0.010 f/ml	Floor condition good

(Kominsky et al., 1998a)

Range 0.004 - 0.018 f/ml — Floor condition poor

Range 0.006 - 0.014 f/ml — Floor condition good

(Kominsky et al., 1998b)

Ultra High Speed Burnishing - previously finished floor polished to high gloss at 1100-2000 rpm

0.87 - 1.16 f/ml	TEM 0.011 - 0.040 s/ml	Floor condition poor
0.67 - 1.02 f/ml	TEM 0.010 - 0.020 s/ml	Floor condition good

TEM results show much lower asbestos concentrations - other “fibres” as defined by PCM counting rules are not asbestos (Kominsky et al., 1998b)

Removal of Floor Tiles (Crossman et al., 1996)

Floor “flooded” for 3 days prior to removal dry with hand tools

0.021 - 0.062 f/ml	Area samples
0.032 - 0.033 f/ml	Area samples

No prior wetting; dry removal with hand tools

0.15 - 0.17 f/ml	Area samples

Floor “flooded” for 3 days prior to removal dry with pneumatic tool

0.079 - 0.12 f/ml	Area samples
0.082 - 0.14 f/ml	Area samples
0.074 - 0.088 f/ml	Area samples
0.048 - 0.11 f/ml	Area samples

Removal of Floor Tiles (Crossman et al., 1996)

No prior wetting; propane torch and hand scrapers

0.006 - 0.022 f/ml	Area samples

Wetting with amended water and long-handled scraper

0.027 - 0.035 f/ml	Area samples

Dry ice to release tiles

0.019 - 0.024 f/ml	Area samples

Removal of mastic by hand-rubbing with abrasive pad

0.048 - 0.054 f/ml	Area samples

Remove flooring products - “representative” (CONSAD, 1990)

0.02 - 0.04 f/ml

Work on Decorative Coatings

Some decorative coatings, contained a small amount of chrysotile fibres (4% and 1.8 % in the two UK products) in an emulsion binder (Derricott, 1979). From 1976, the UK forms of Artex no longer used asbestos. With the low asbestos content and flexible matrix, exposures rarely exceed 1 f/ml (e.g. when the coating is removed dry with power chisels). Wetting does not always seem to be effective in reducing the fibre concentration possibly because the water does not easily penetrate into the emulsion binder but proprietary solvent removers are available .

<u>Table 11: work on decorative coatings (artex) Personal Exposure to Asbestos during:</u>

<u>Removal of coating</u>	
Dry with power chisels	0.27 - 1.17 f/ml
Water jet	<0.01 - 0.02 f/ml
Gel to soften, then hand scrapers, debris swept into plastic sacks	
	0.03 - 0.14 f/ml
	0.01 - 0.03 f/ml
Sealed with PVA, steam-master and hand scraper	<0.01 f/ml
<u>Work on walls with decorative coating</u>	
Removal of fittings from wall - wet suppression, hand tools	
<0.01 f/ml	
<0.05 f/ml	
<0.03 f/ml	
0.37 f/ml	
Drilling (domestic premises)	
Mean 0.16 f/ml Max 0.16 f/ml (Burdett & Revell, 1998)	
Knocking down walls, shoveling rubble into sacks - hand tools, no suppression	
	0.079 - 0.232 f/ml
Knocking down walls, shoveling rubble into sacks - hand tools, wetting with spray	
	0.13 - 0.156 or <0.209 f/ml
	<0.12 - 0.20 or < 0.21 f/ml
Ripping off architrave, gouging walls (simulated vandalism)	
	0.52 - 0.74 f/ml
Crushing rubble from demolition of flats with Artex paint left on stairwells	
	<0.01 f/ml.

(All data from Stacey (2000) except where noted).

Work on Walls and Asbestos Insulation Board

High exposures are found for work on wallboards when cutting them (Hanaoka & Ebihara, 1998) , but careful maintenance work produces significantly lower levels.

Table 12: work on walls and asbestos insulation board personal exposure to asbestos (Consad, 1990)

Repair drywall (average)		0.75 f/ml
Repair drywall - "representative"		0.02 - 1.4 f/ml
Drywall demolition for renovation/remodelling - "representative"		0.15 - 11 f/ml
Insulation board Short term maintenance work (Burdett & Revell, 1998)		
Domestic - removal of AIB	0.01 f/ml	
Schools, etc. - removal of AIB	Mean 0.49 f/ml	Max 0.72 f/ml
Engineer (domestic) - door panel	Mean 0.23 f/ml	Max 0.62 f/ml
Engineer (domestic) - side/base panel	Mean 0.46 f/ml	Max 0.77 f/ml
Engineer (domestic) - side/base/door panel	Mean 0.31 f/ml	Max 0.77 f/ml

Other types of work

Various other types of maintenance work are summarised in table 13

Table 13: Other types of work personal exposure to asbestos from:

Asbestos Removal (Unlicensed)		
Gas fitter (domestic)	Mean 0.34 f/ml	Max 0.68 f/ml (BR)
Boiler Work		
Repair boiler (average)		0.18 f/ml (C)
Repair boilers - "representative"		0.04 - 0.53 f/ml (C)
Removal/repair of boiler insulation - "representative"		<0.01 - 8 f/ml (C)
Inspector - boiler house	Mean 0.01 f/ml	Max 0.02 f/ml (BR)
Pipe work and Central Heating		
Removal/repair of pipe insulation - "representative"		<0.01 - <0.1 f/ml (C)
Unspecified (domestic) - pipes	Mean 1.1 f/ml	Max 3.06 f/ml (BR)
Plumber/carpenter (domestic) - pipes	Mean 0.39 f/ml	Max 0.65 f/ml (BT)

Work on Ducts

Electrician (hospital) - ducts	Mean 0.01 f/ml	Max 0.01 f/ml (BR)
Unspecified (domestic) - heater/ducting	0.01 f/ml (BR)	
Unspecified (schools, etc.) - duct/valves	Mean 0.08 f/ml	Max 0.36 f/ml (BR)
Flue Pipes		
Engineer (domestic)	Mean 0.01 f/ml	Max 0.01 f/ml (BR)
Plumbing		
Repair plumbing (average)	0.11 f/ml (C)	
Repair plumbing - "representative"	0.04 - <0.1 f/ml (C)	
Domestic - fitted cabinets	Mean 0.05 f/ml	Max 0.06 f/ml (BR)
Maintenance/Other		
Miscellaneous activities - "representative"	<0.01 - 2.8 f/ml (C)	
Demonstrator (domestic) - thermal seal	Mean 0.54 f/ml	Max 0.58 f/ml (BR)
Electrician (domestic)	Mean 0.02 f/ml	Max 0.02 f/ml (BR)
Electrician (hospital) - cable pulling	Mean 0.05 f/ml	Range 0.024 - 0.099 f/mlS
Electrician (hospital) - generator testing	Mean 0.084 f/ml	Range 0.008 - 0.226 f/mlS
Electrician (hospital) - fire alarm testing	Mean 0.165 f/ml	Range 0.084 - 0.269 f/mlS
Maintenance of air-handling units (hospital)	Mean 0.09 f/ml	Range 0.009 - 0.68 f/ml S
Miscellaneous repair in hospital	Mean 0.13 f/ml	Range 0.004 - 0.55 f/ml S
Miscellaneous installation in hospital	Mean 0.17 f/ml	Range 0.005 - 0.84 f/ml S
Clean up of ACM in hospital	Mean 0.2 f/ml	Range 0.04 - 0.62 f/ml (S)
Gas fitter (domestic) - servicing	Mean 0.1 f/ml	Max 0.47 f/ml (BR)
Gas fitter (domestic) - RACO	Mean 0.02 f/ml	Max 0.1 f/ml (BR)
Gas fitter (domestic) - simulation	Mean 0.4 f/ml	Max 0.72 f/ml (BR)
Inspector (domestic)	Mean 0.09 f/ml	Max 0.12 f/ml (BR)
Inspector (garage)- damaged asbestos	1.44 f/ml (exceptional) (BR)	
Joiner (domestic)	Mean 0.03 f/ml	Max 0.03 f/ml (BR)

Literature abbreviations

C CONSAD (1990)

BR Burdett & Revell (1998)

S Shaikh et al. (1994)

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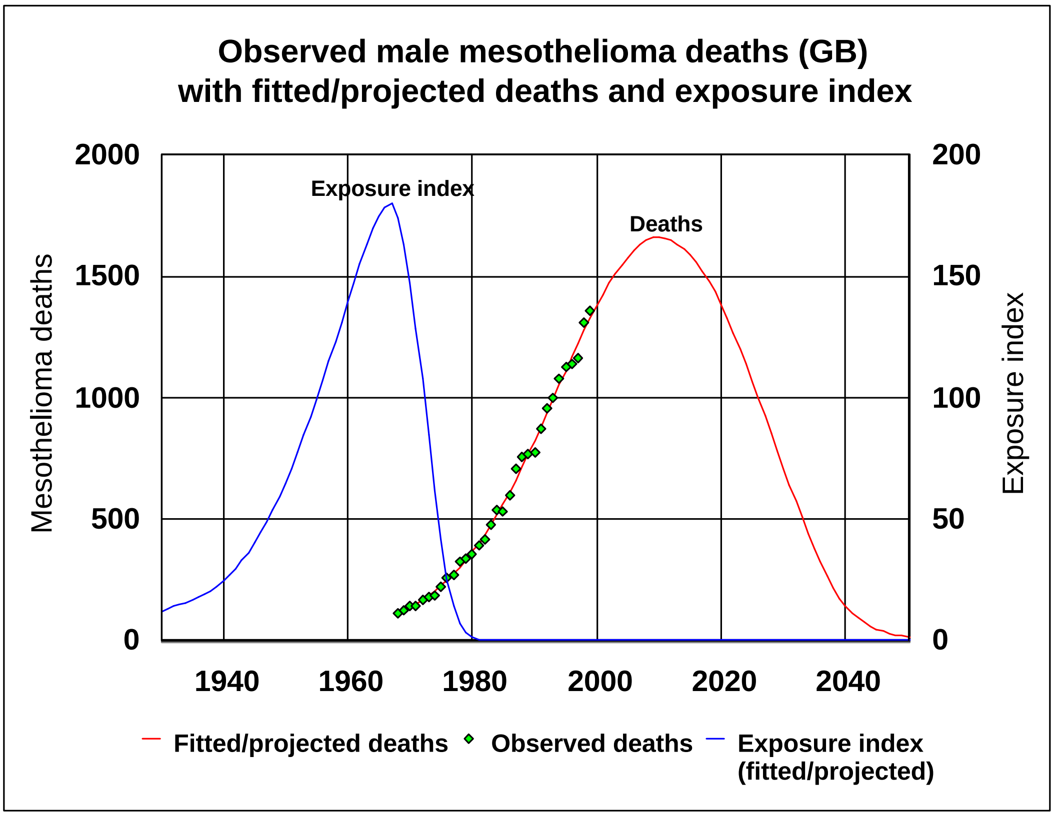
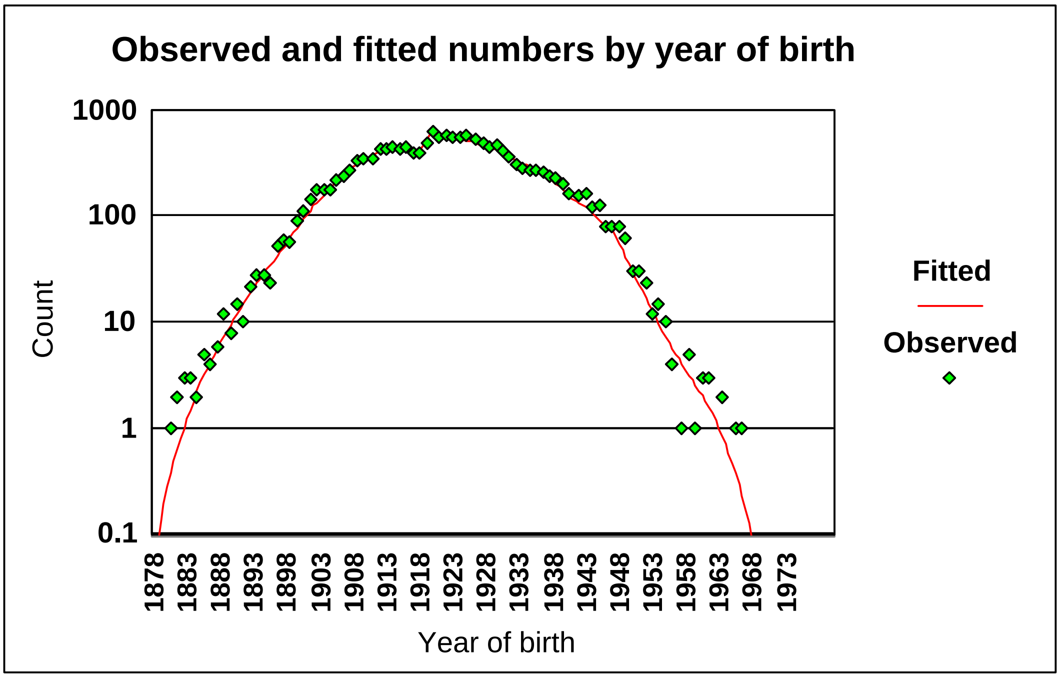
Appendix 2 (Graphical representation of risks)

Figure 1: Observed and fitted values for male mesothelioma in main modelif

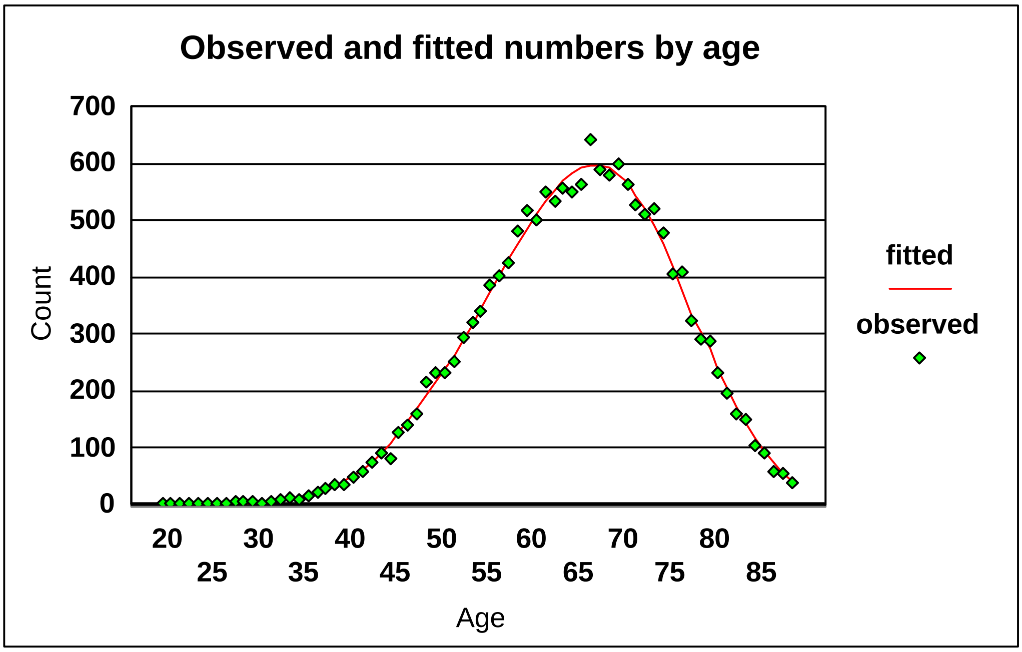
(a) by year



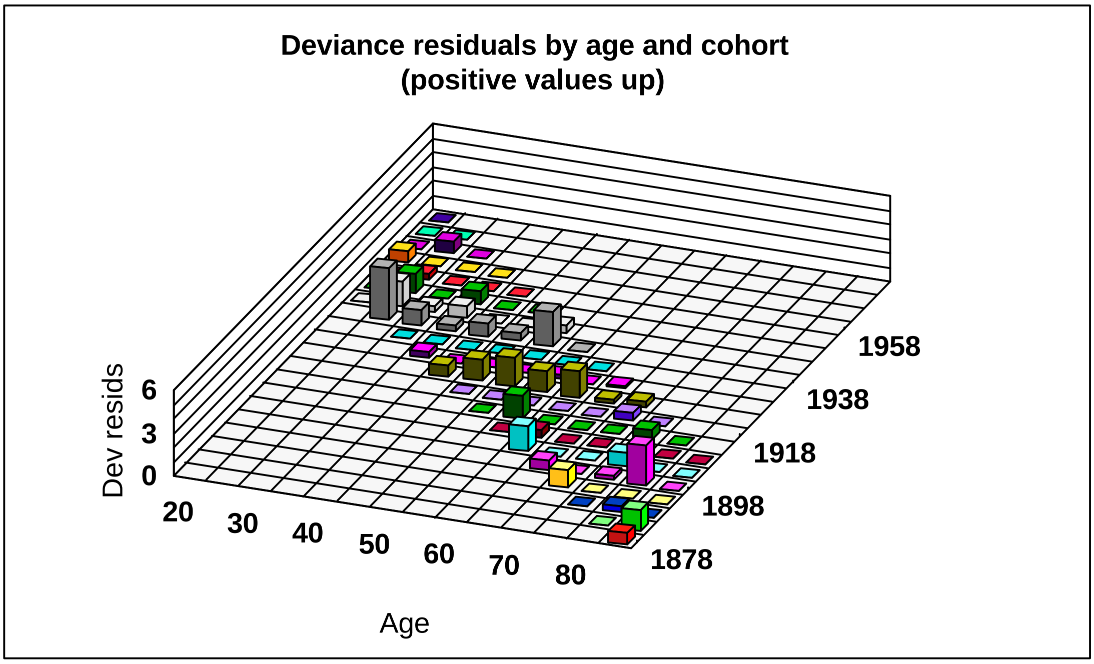
(b) by year of birth

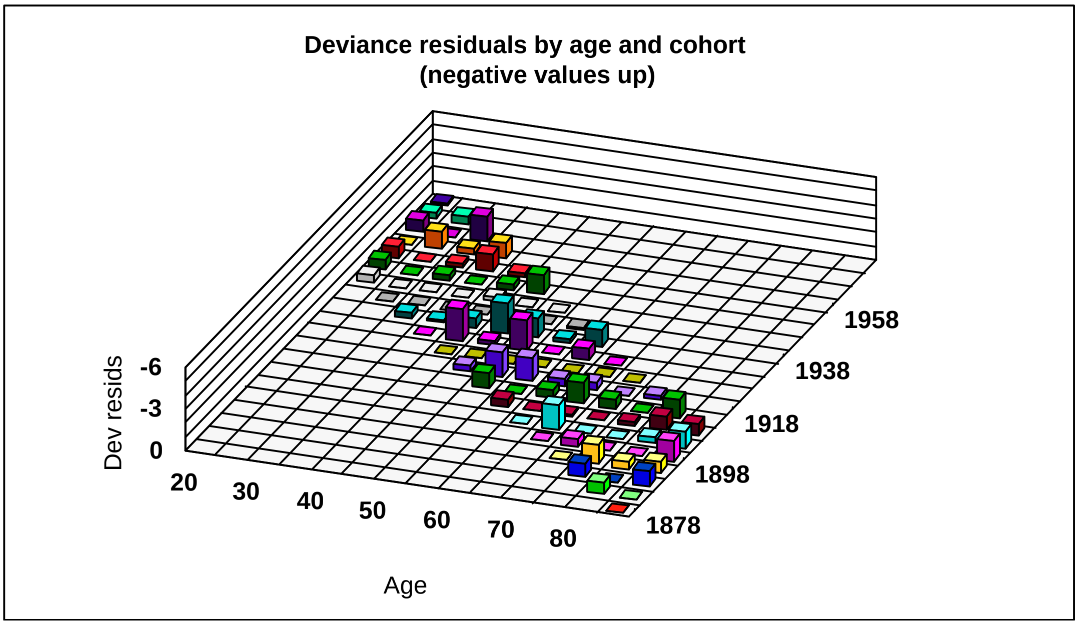


(c) by age



(d) By age and birth year in five-year groups





Note:
Deviance residuals measure the difference between observed and expected values in a standardised form. For a satisfactory fit, not more than one in 20 values should fall outside the range (-2, 2). For this model slightly more (7 of the 98) residuals lie outside this range

Figure 2: Comparison of fitted exposure index with import volumes

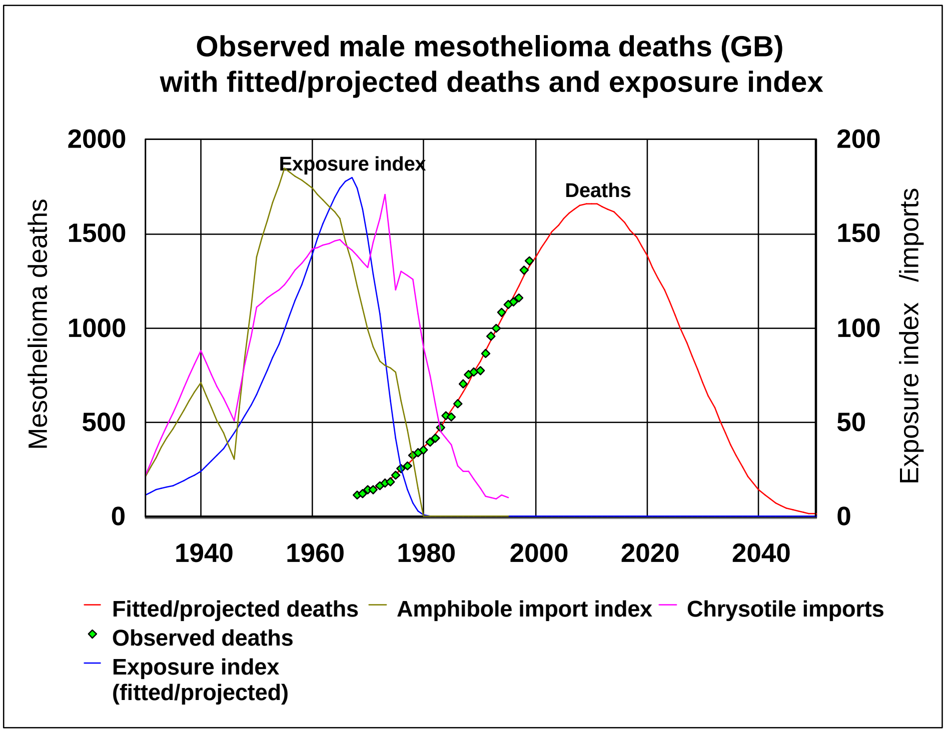


Figure 3: Effect of levelling off exposure at 1977 level

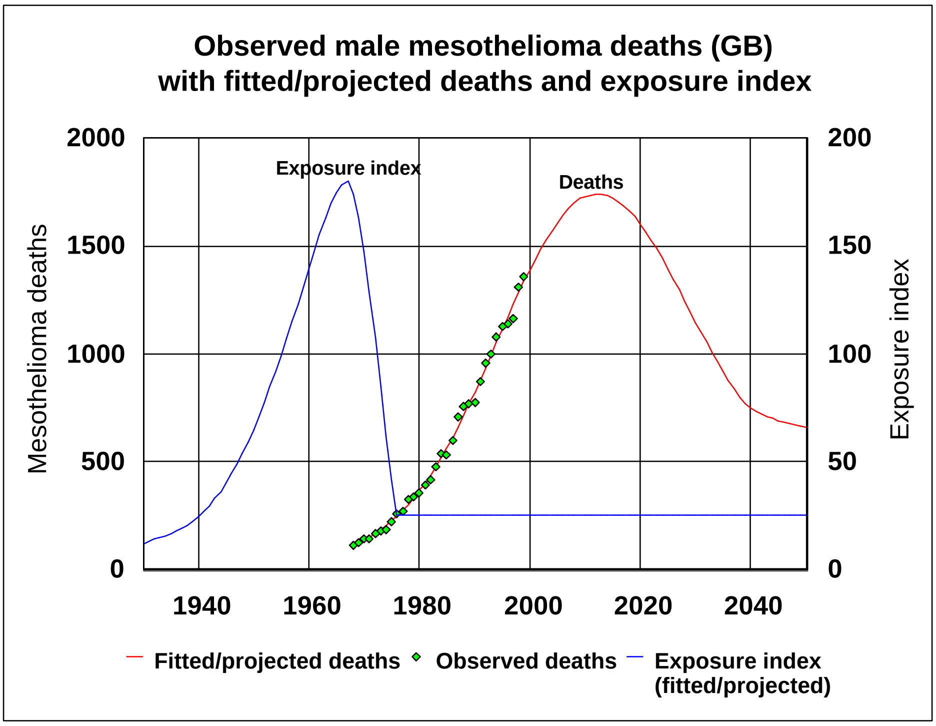


Figure 5: The best case model